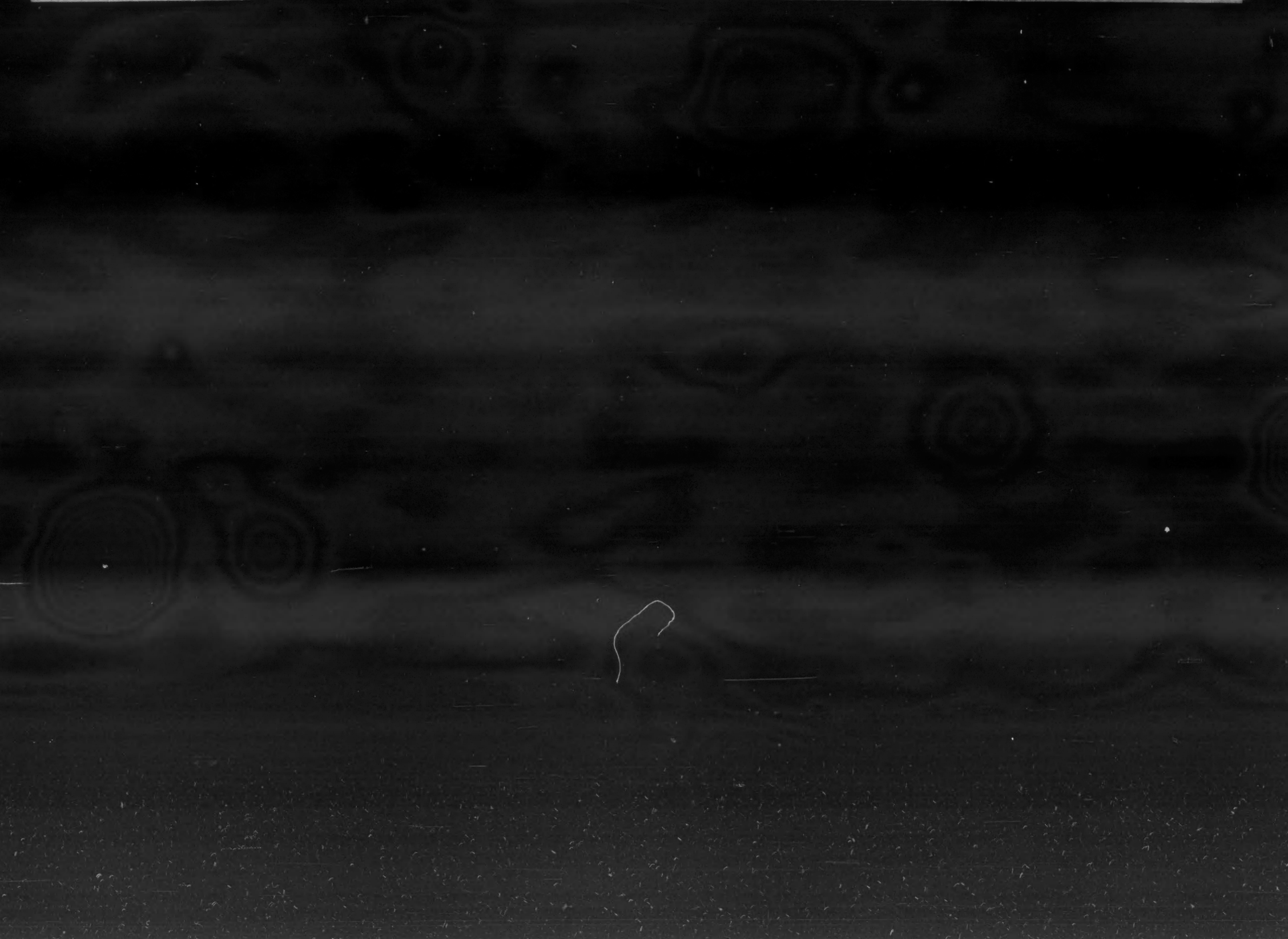

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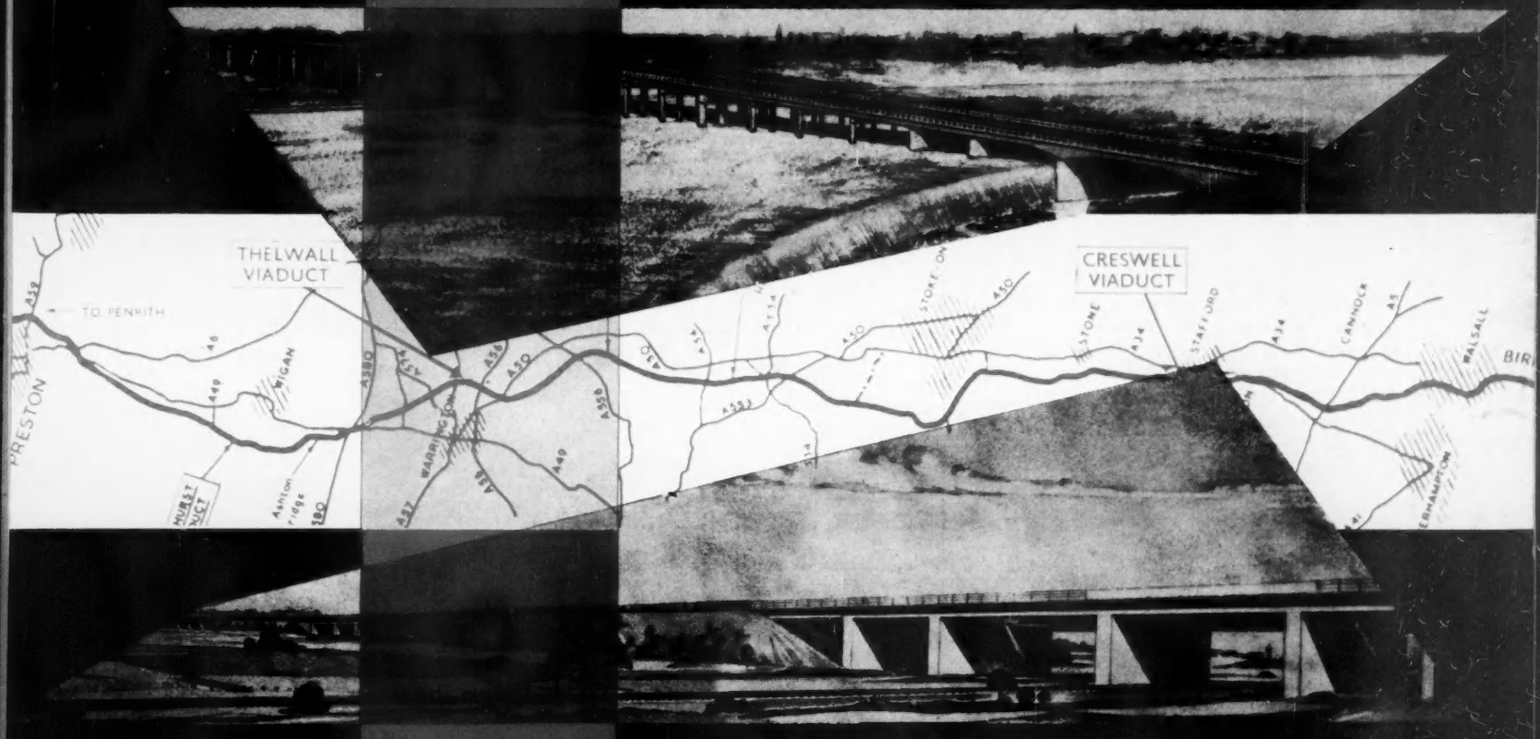

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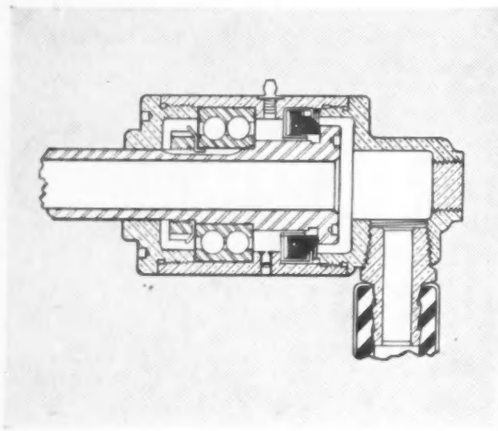
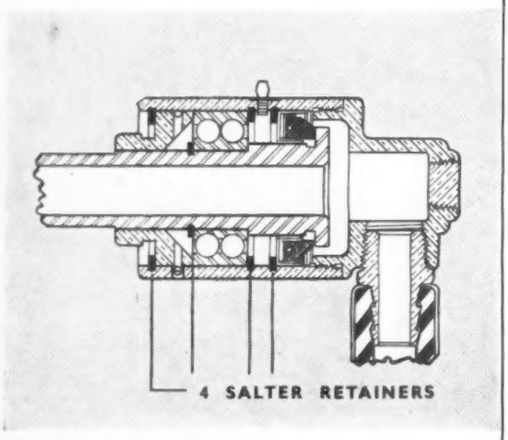


THE OLD WAY Air, water, steam union involved drilling, threading and milling operations. Maintenance was difficult.



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No. 5430 **FEBRUARY 19, 1960** VOL. 209

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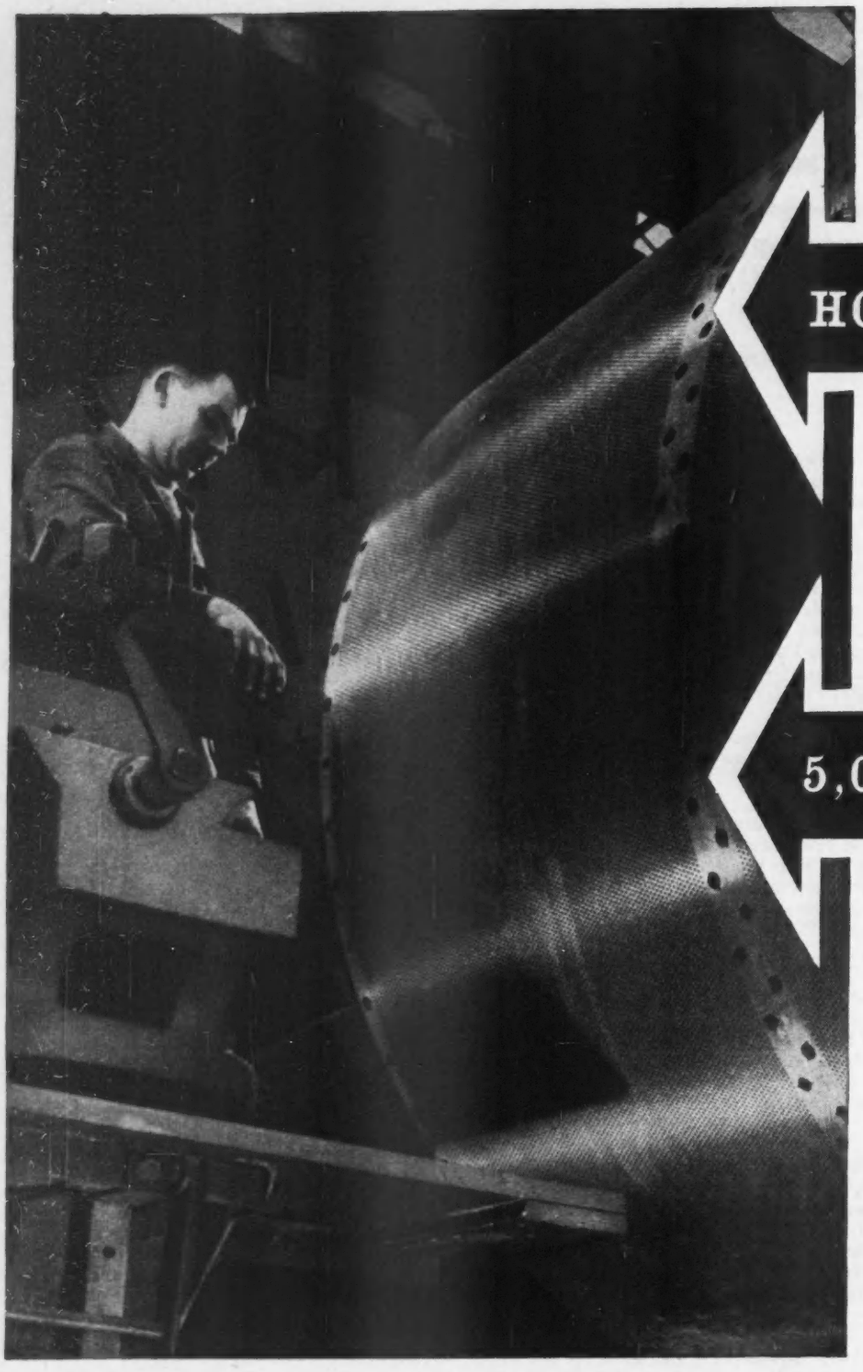

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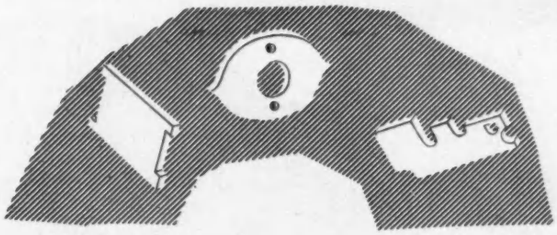

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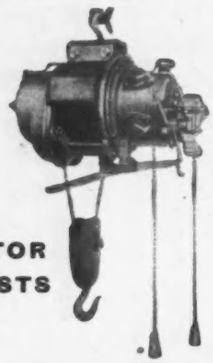

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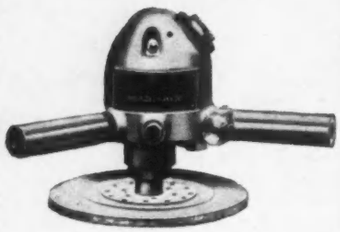

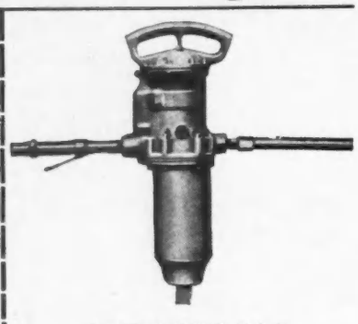

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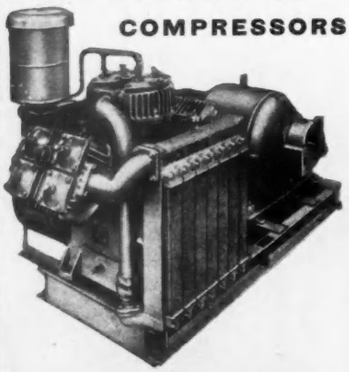

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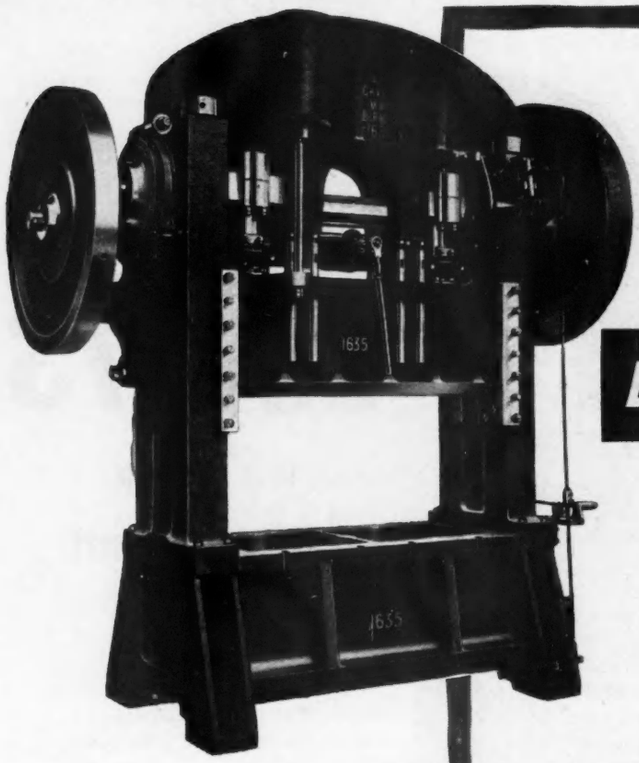

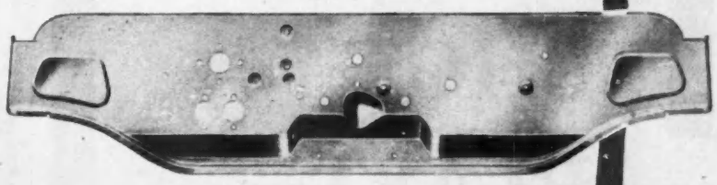

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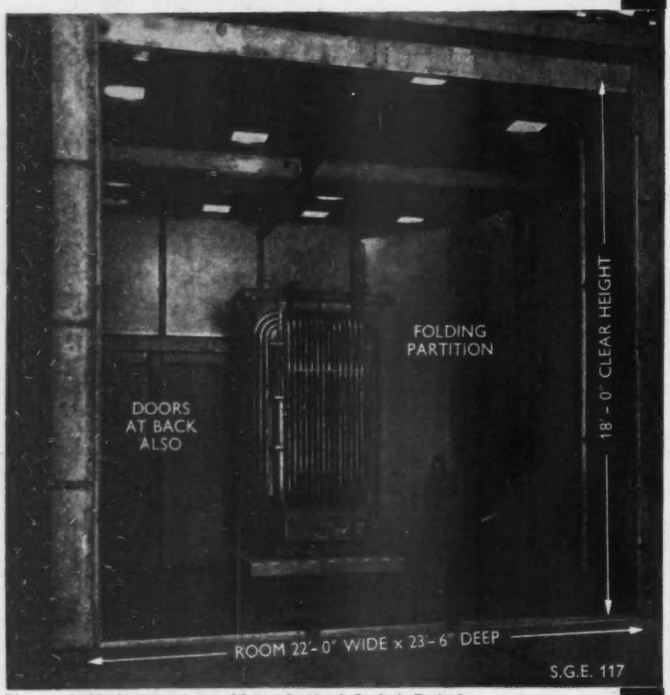

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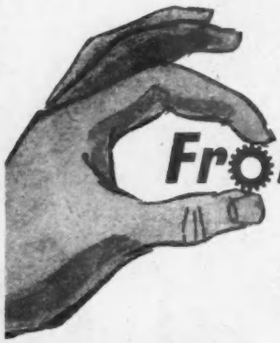

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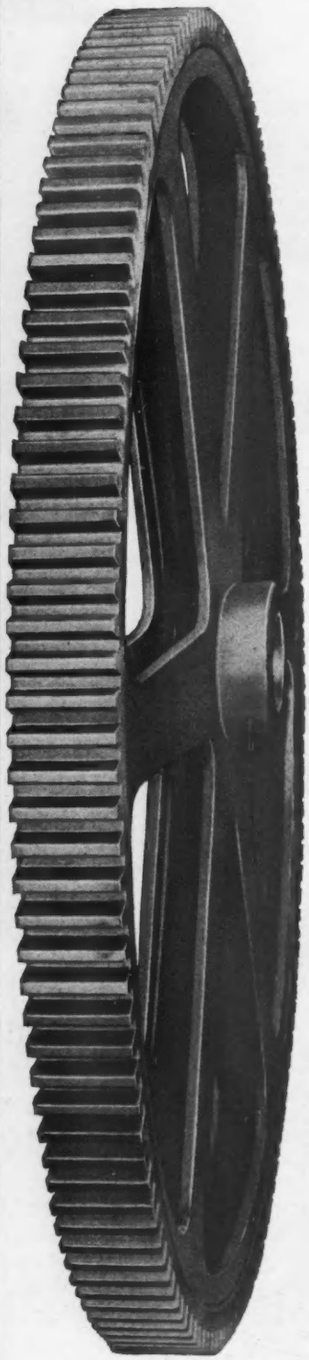

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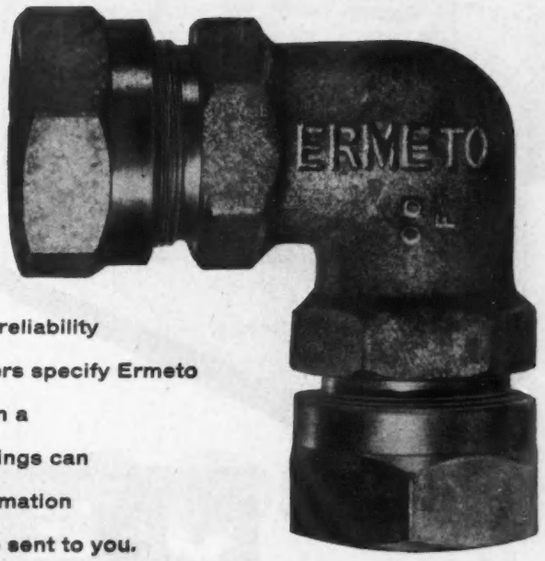

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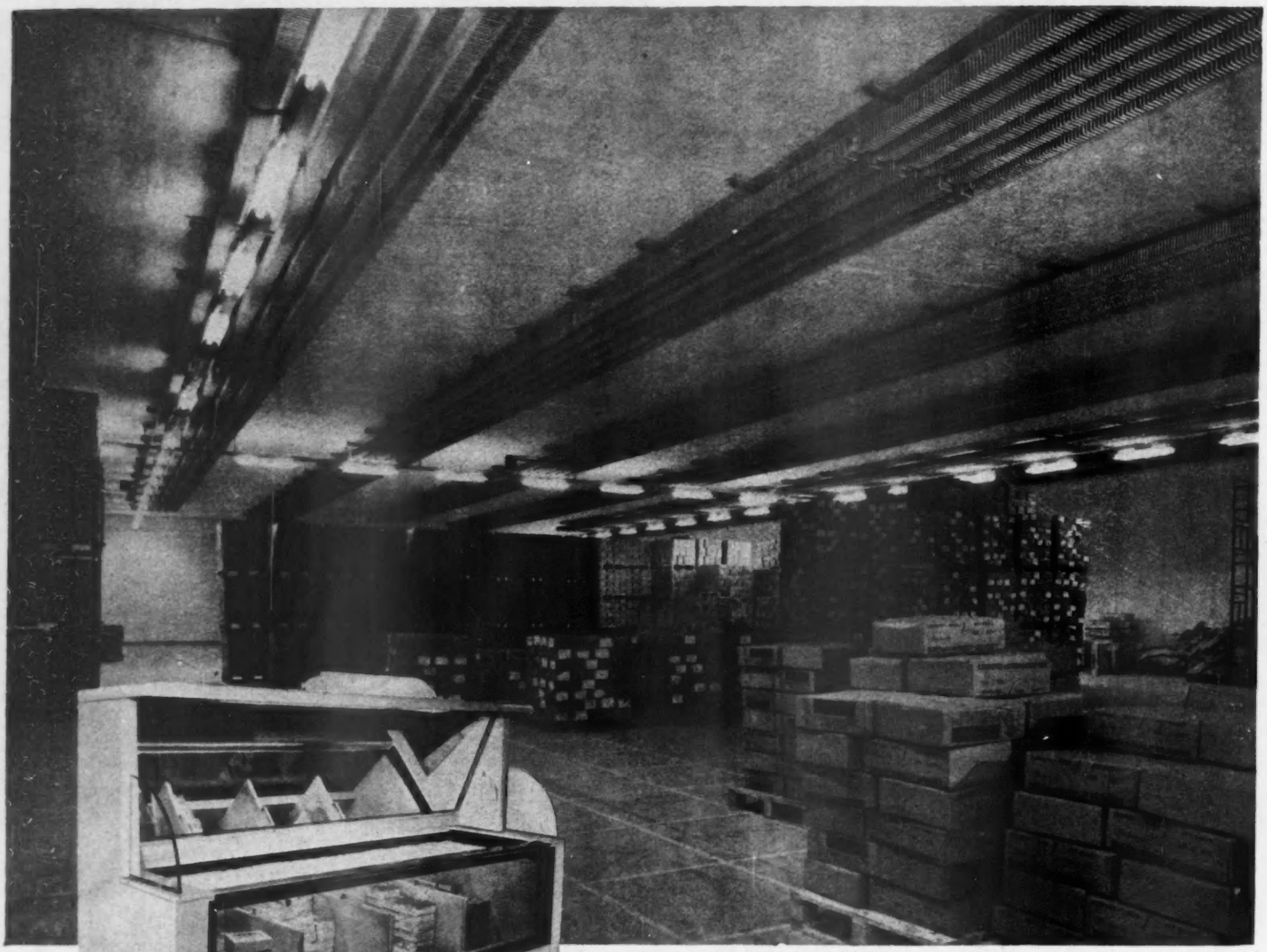

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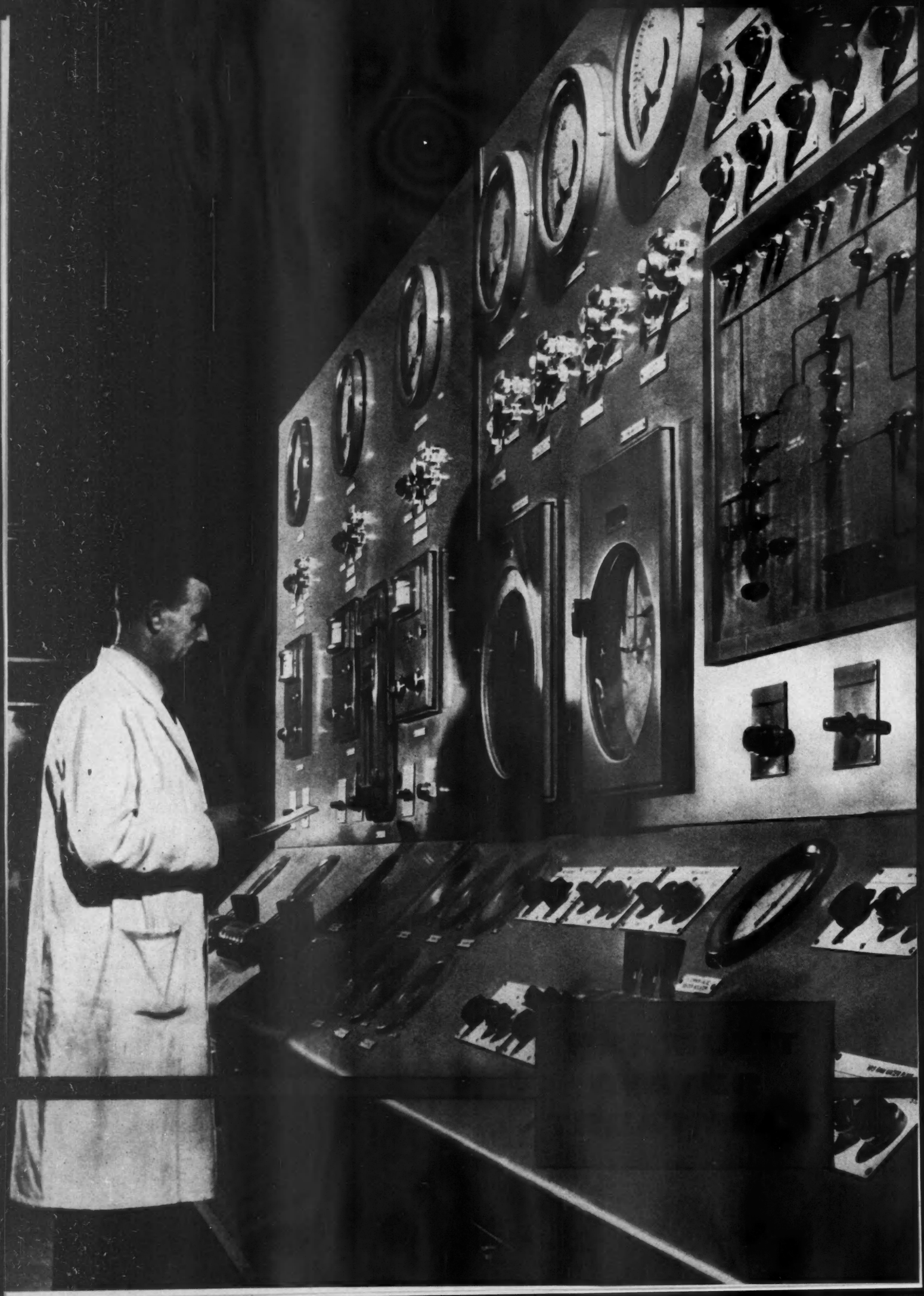

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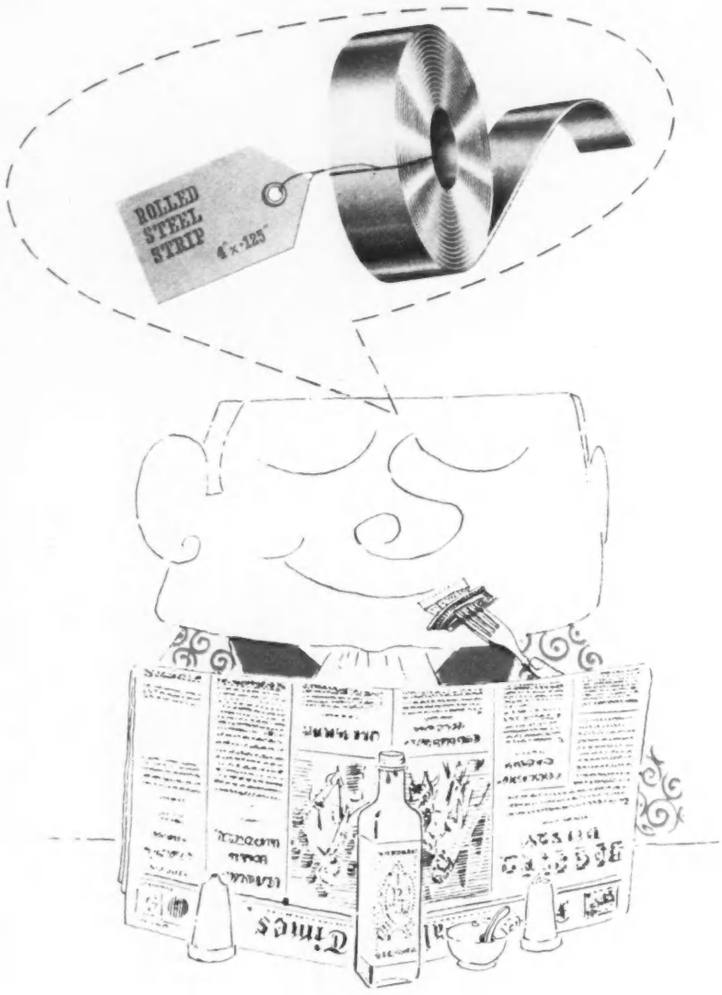

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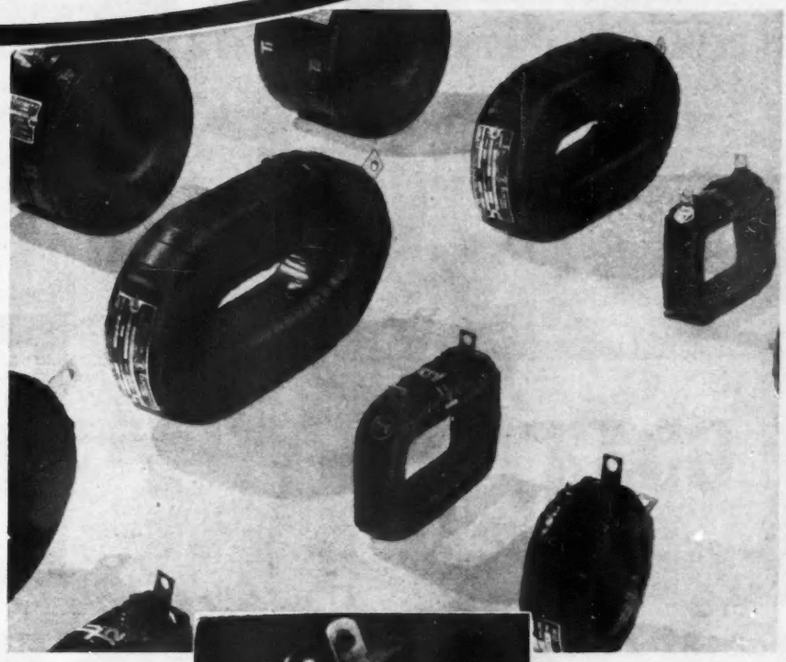

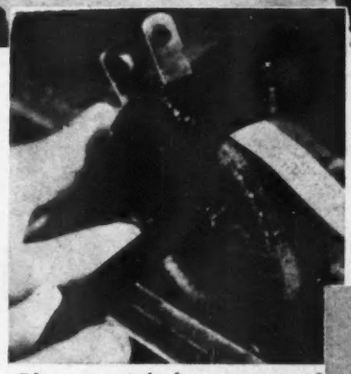

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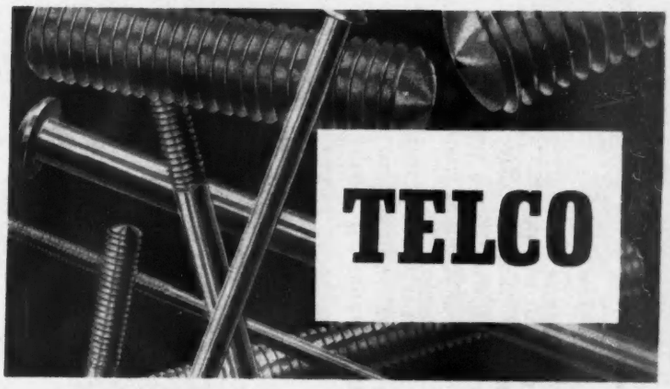

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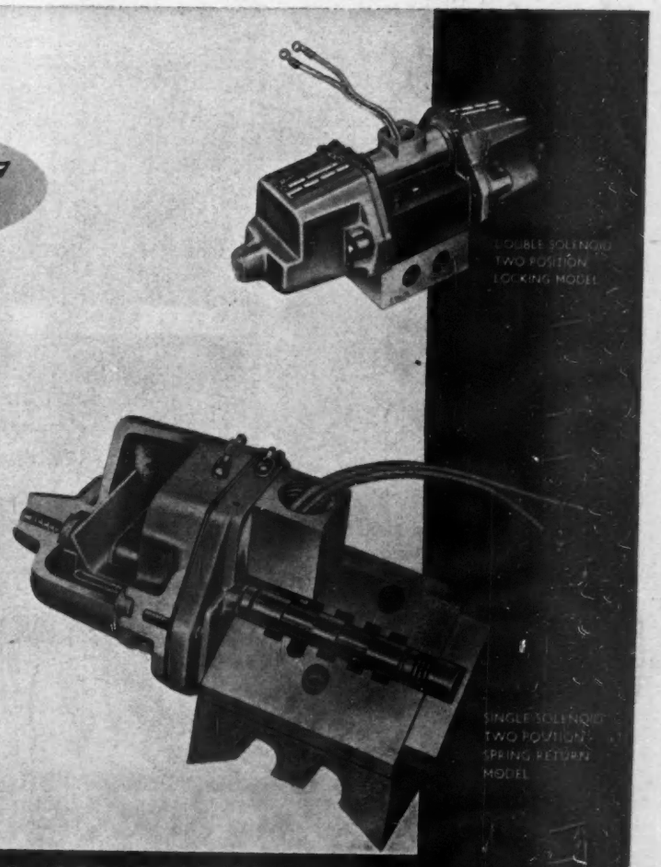

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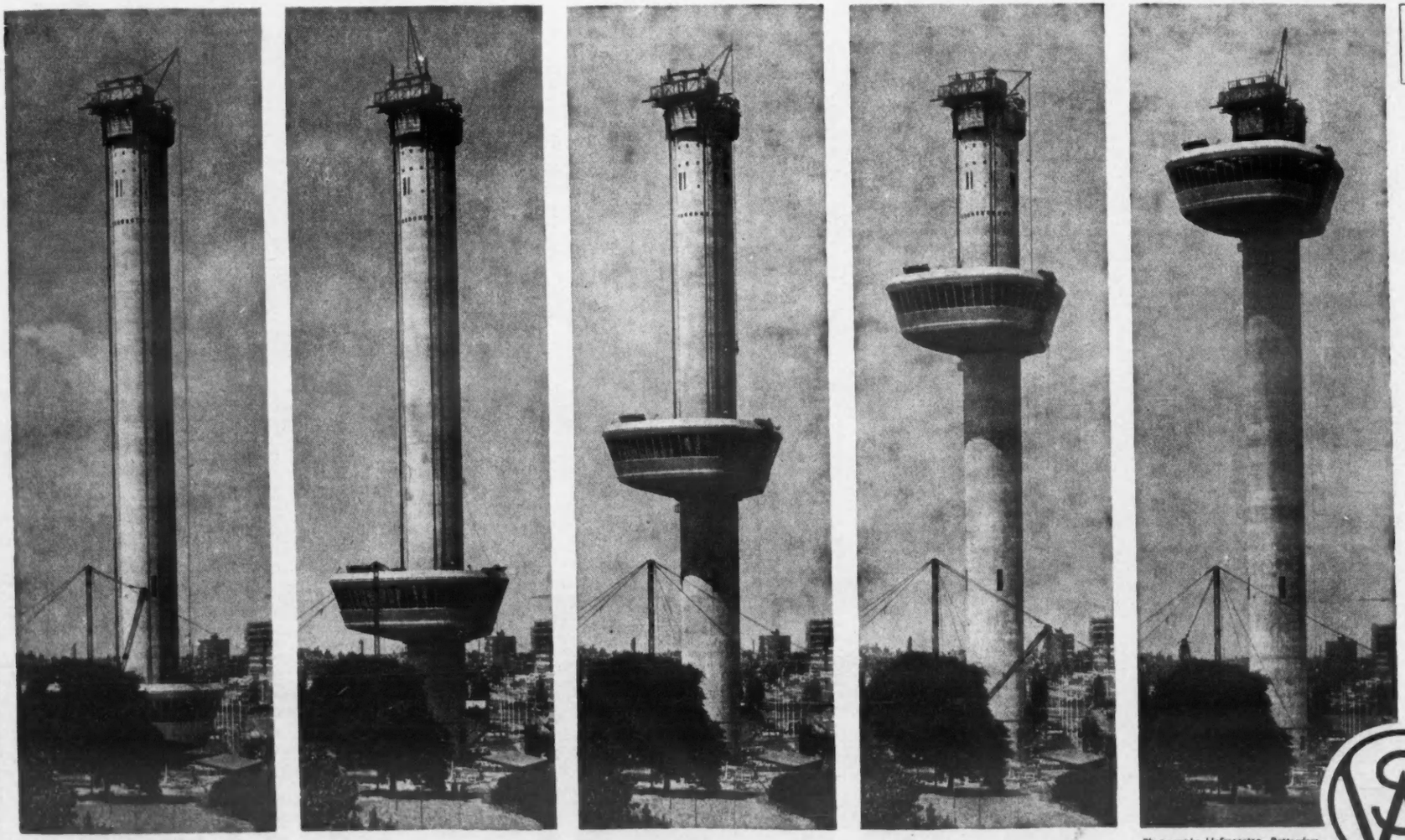

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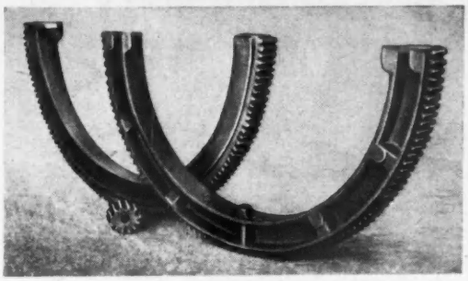

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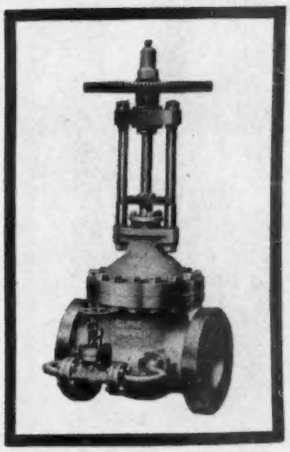

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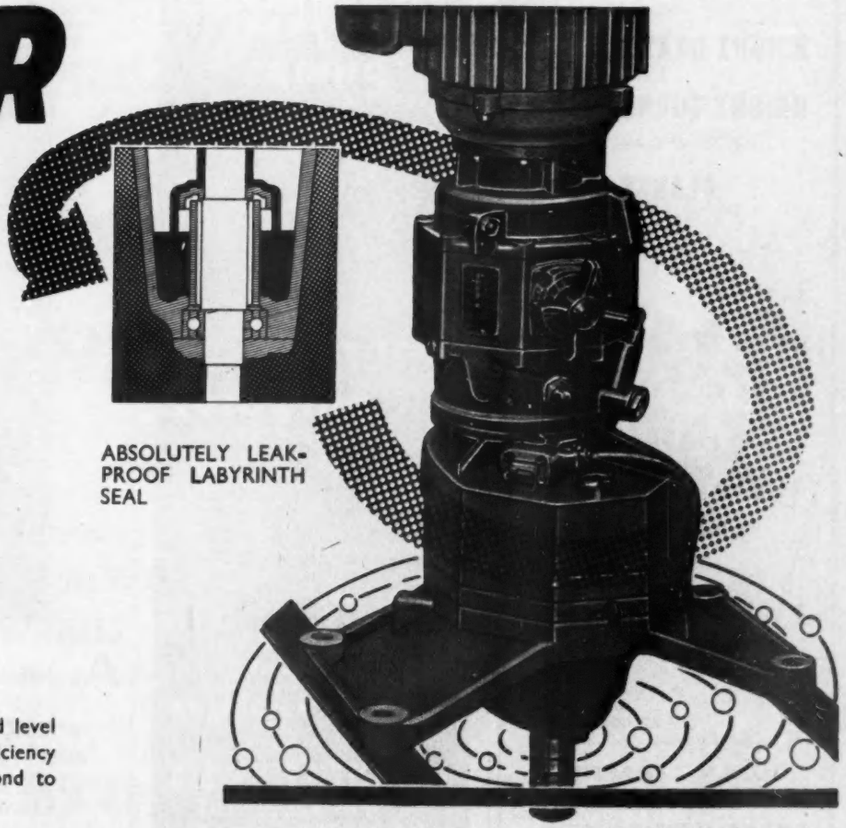

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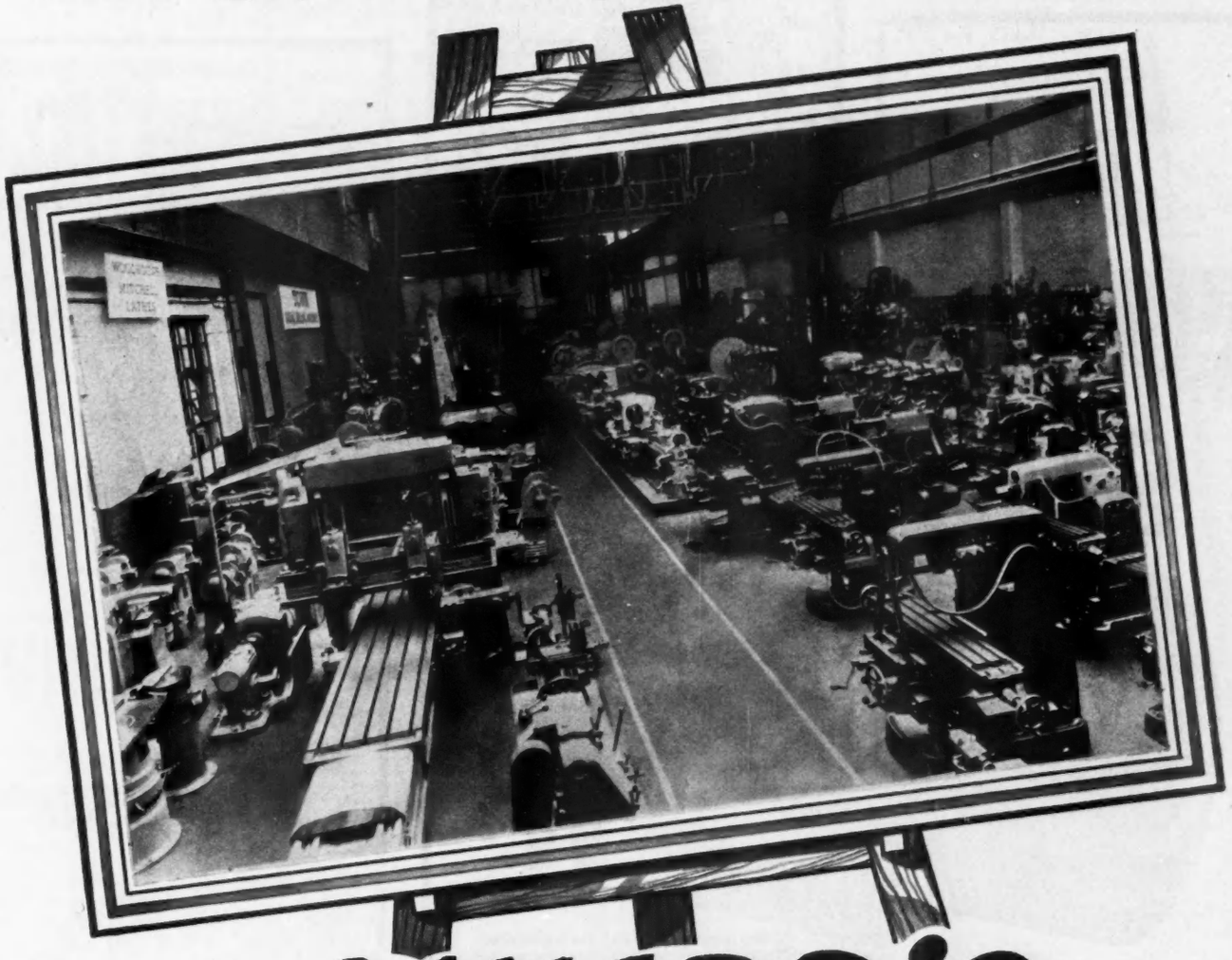

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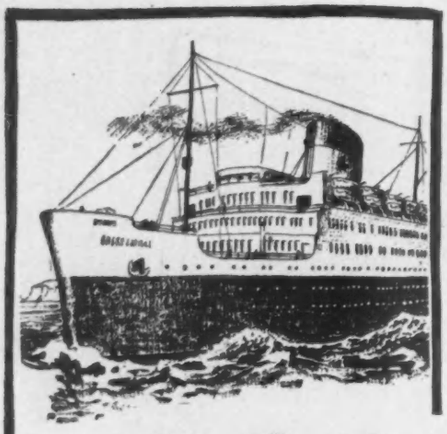

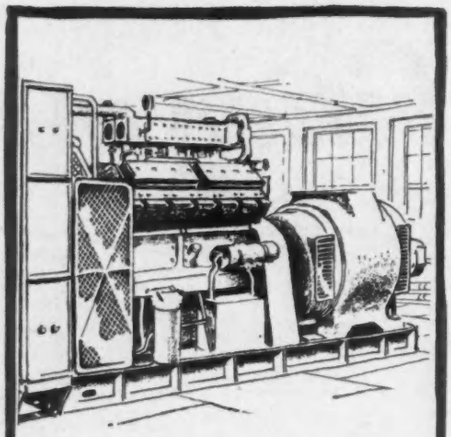

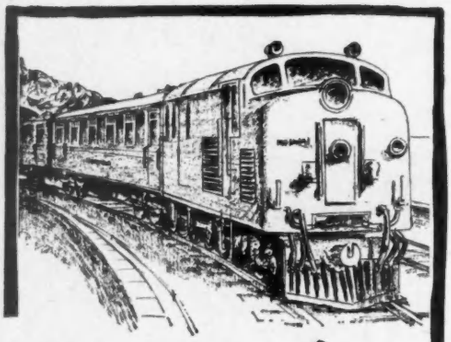

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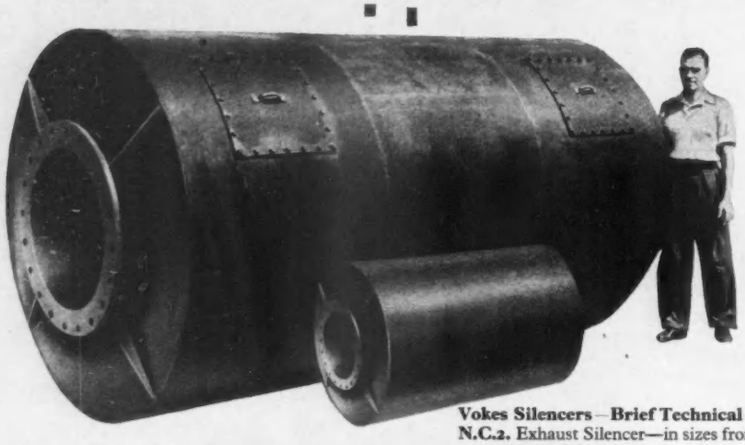

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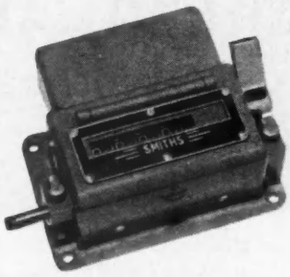

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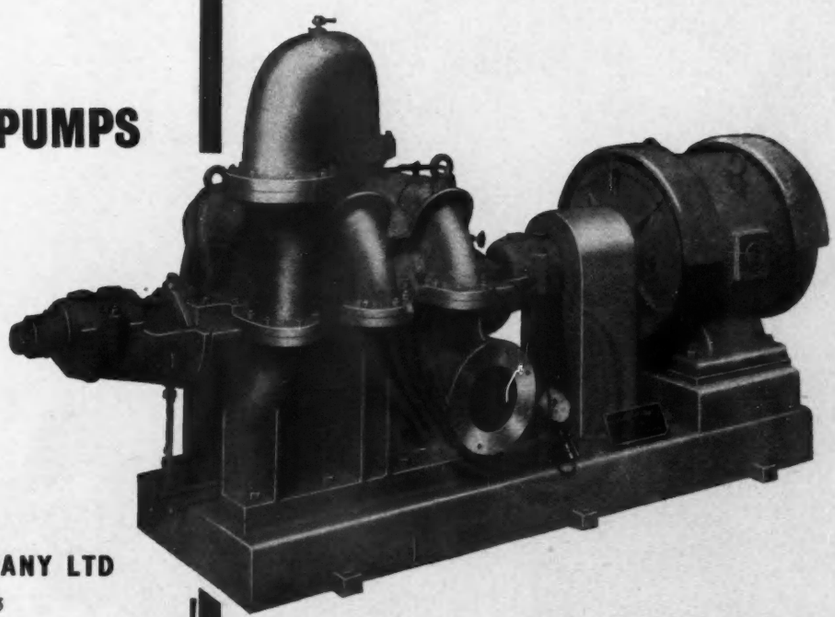

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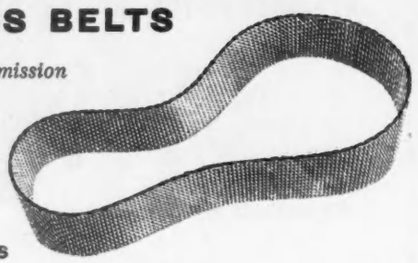

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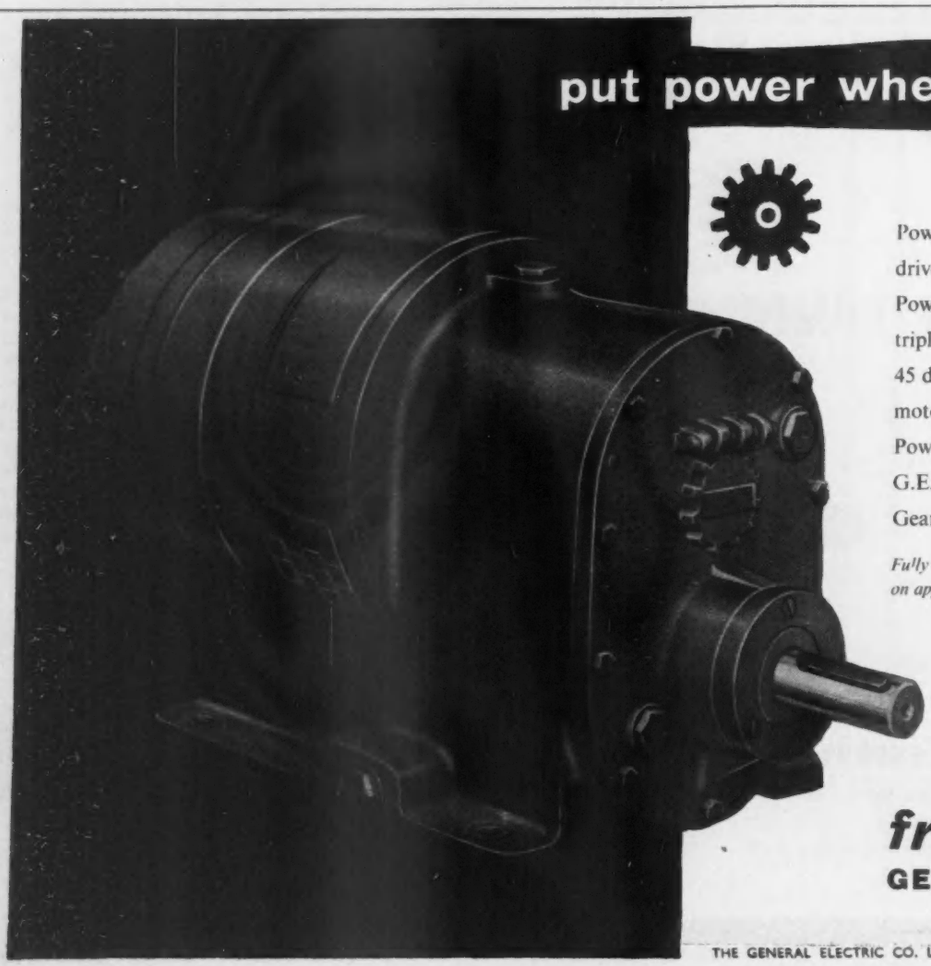

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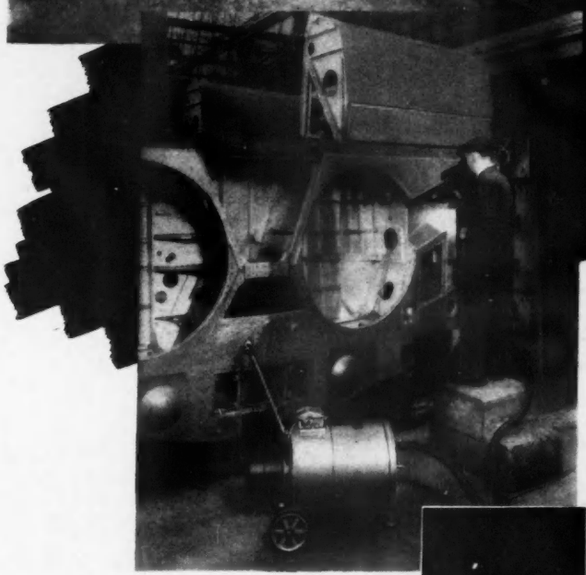

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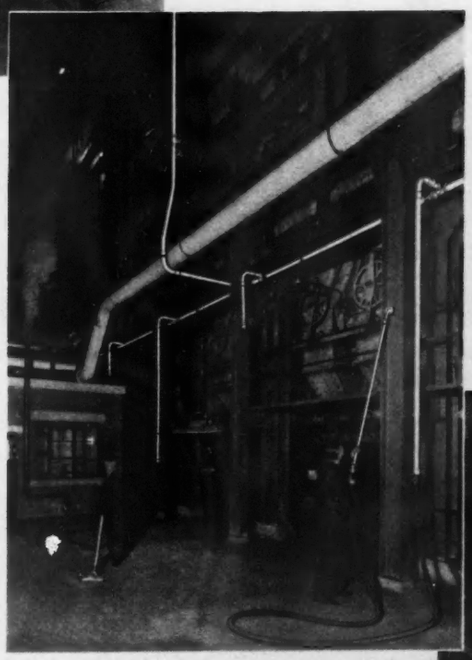

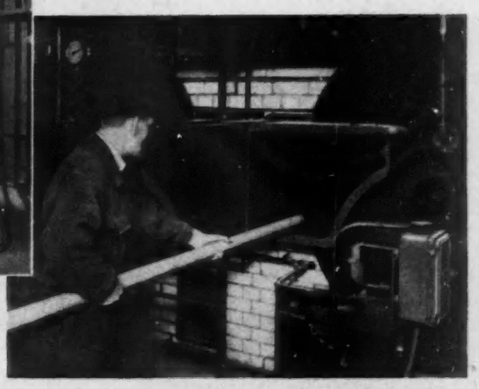

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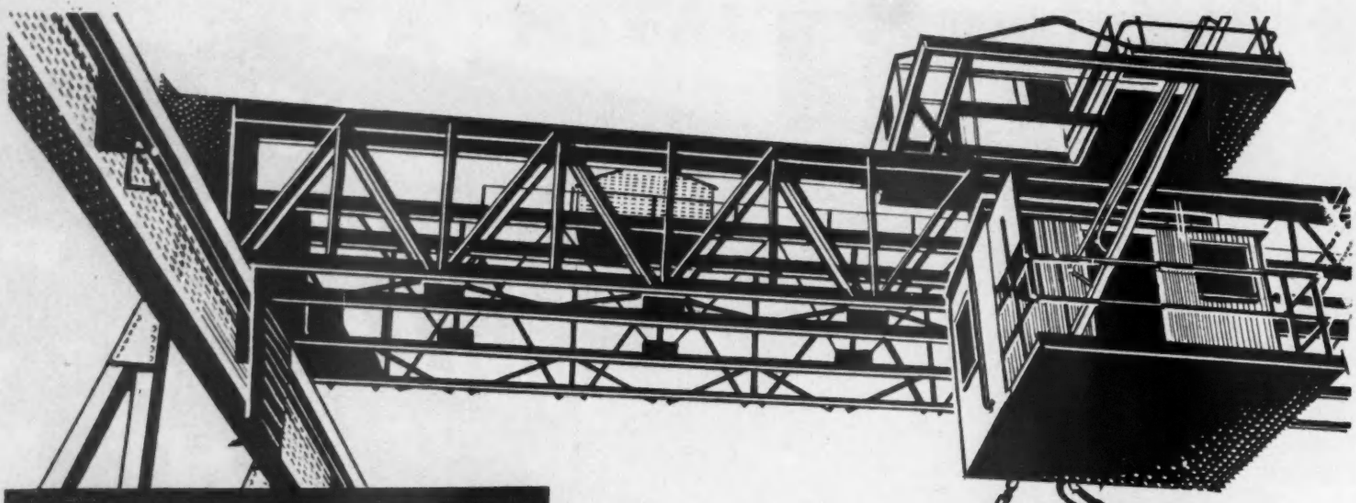

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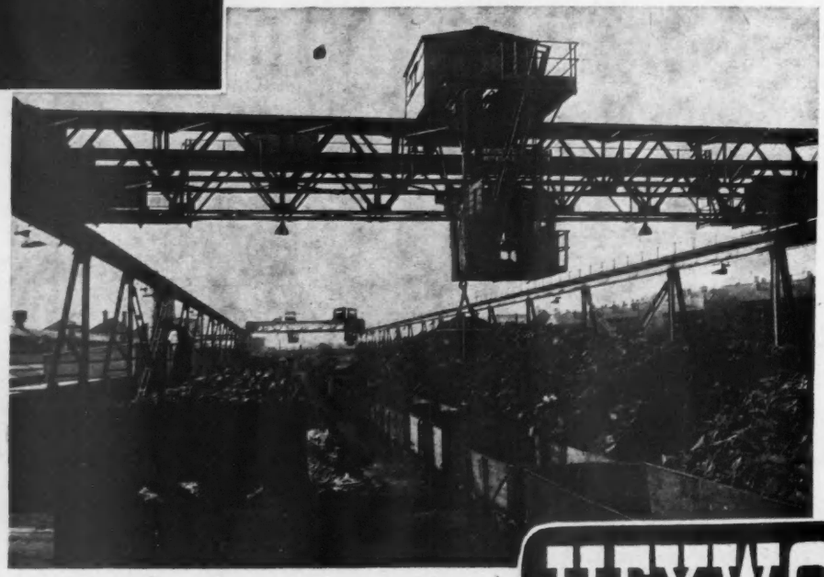

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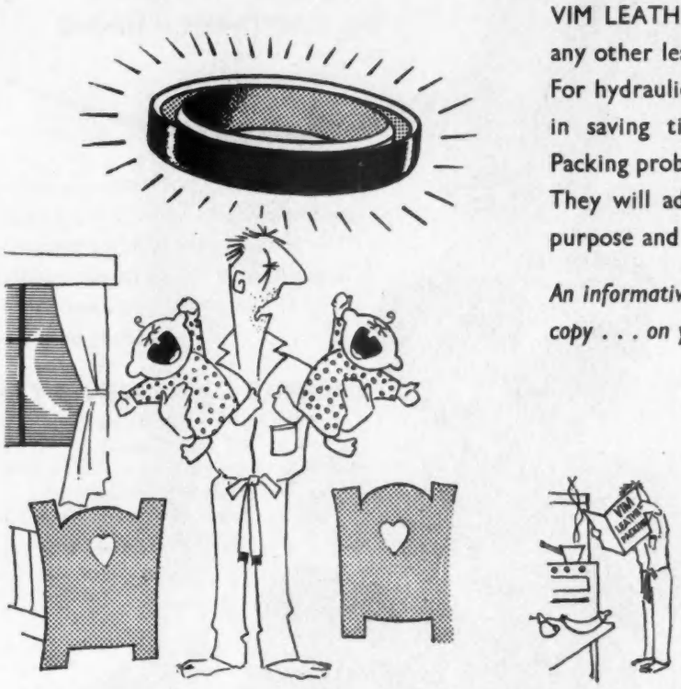

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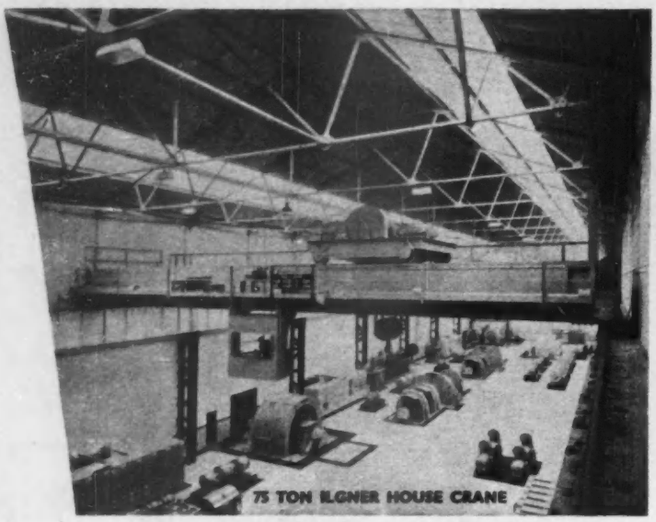

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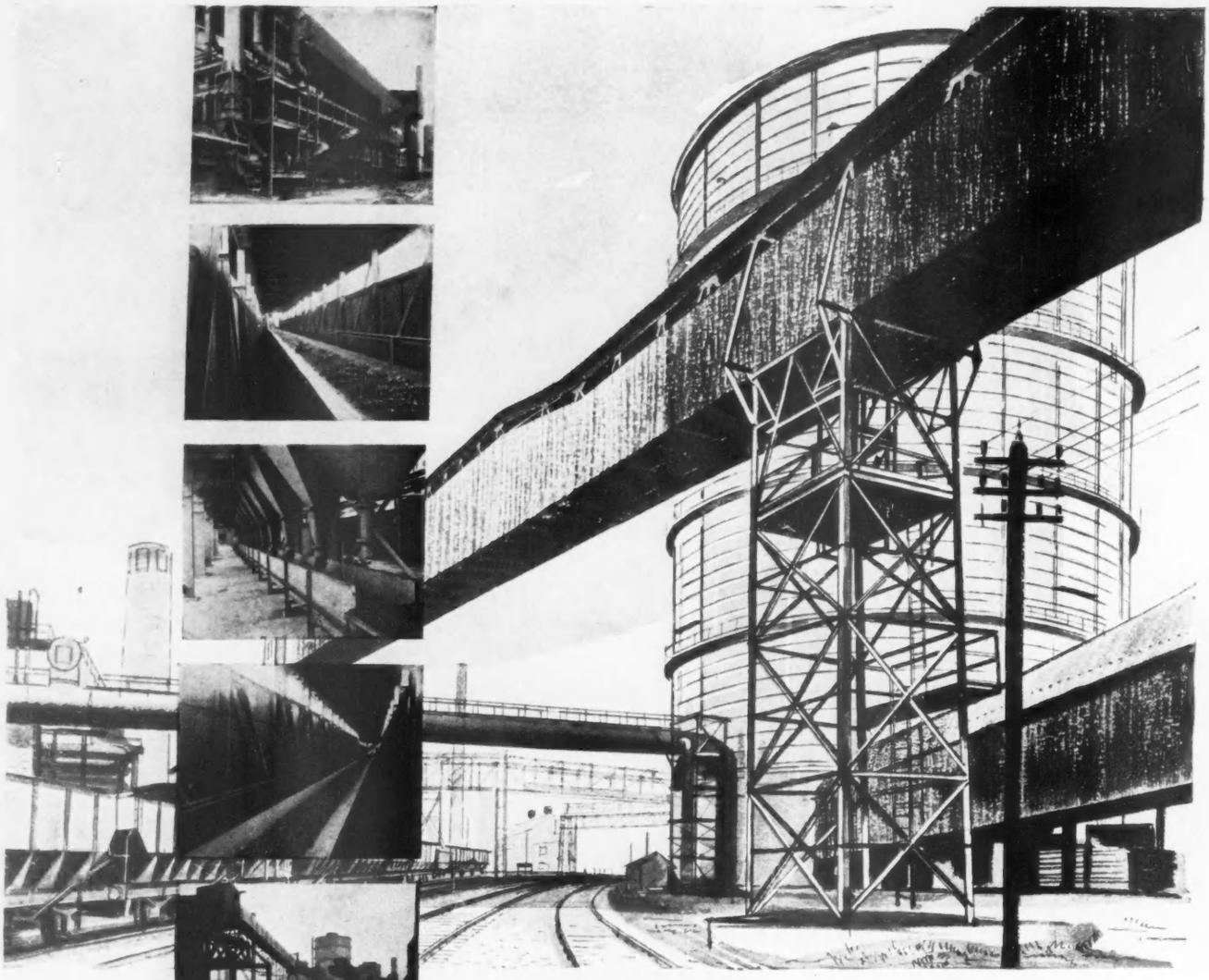

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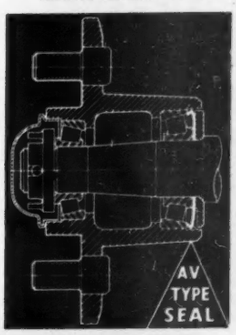

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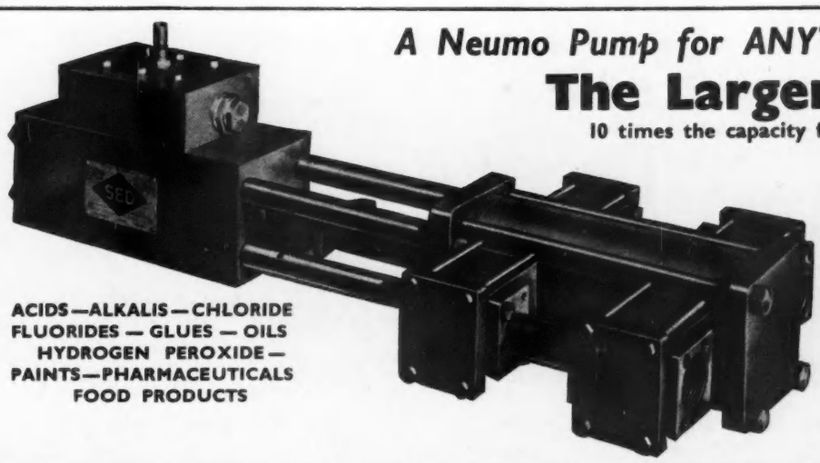

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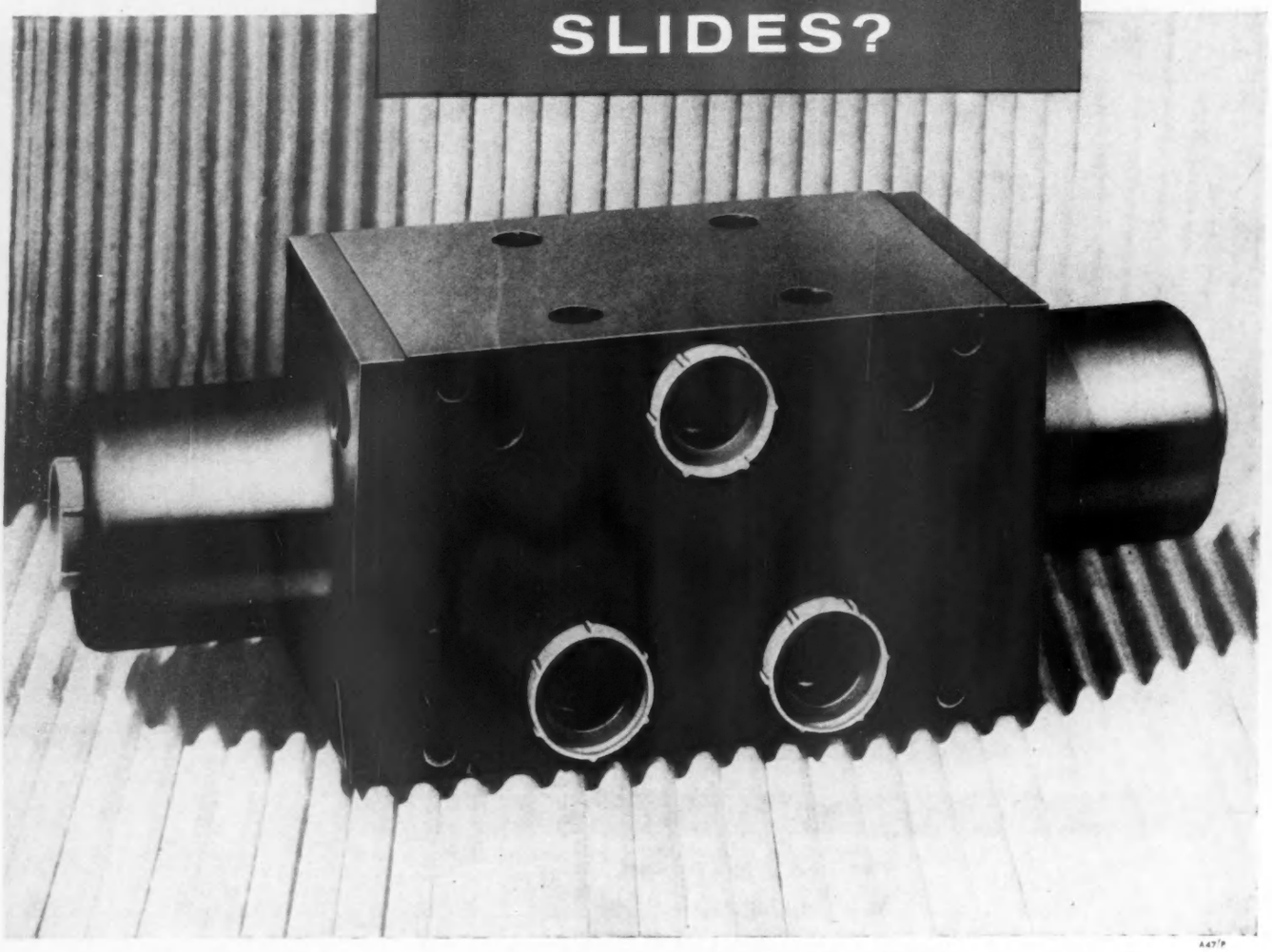
Patent applied for



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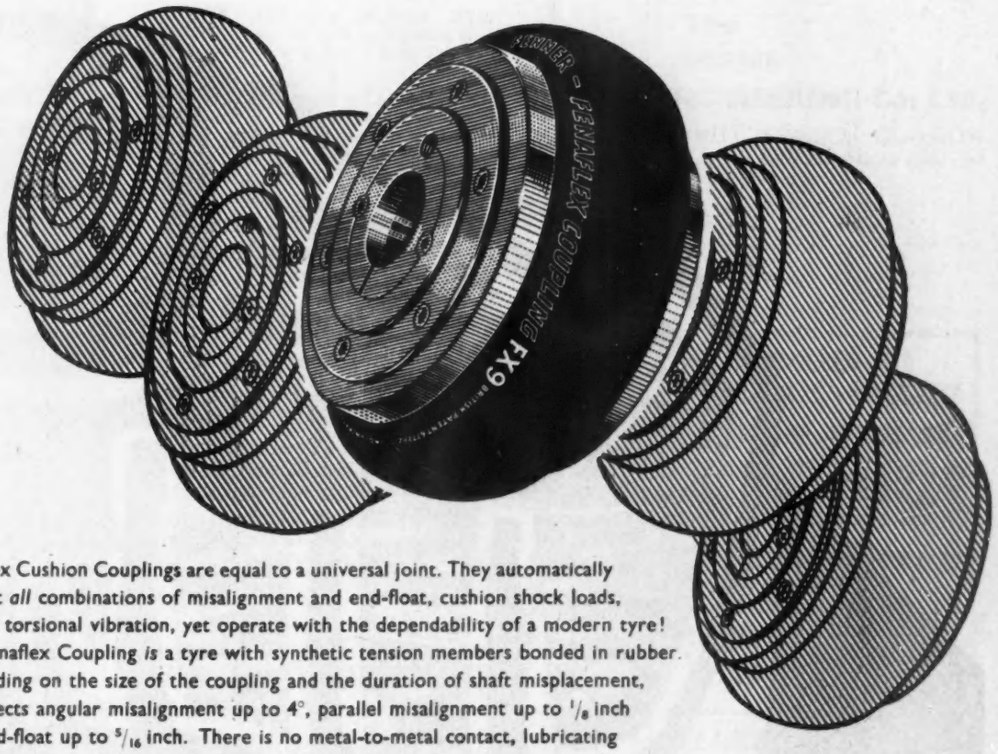

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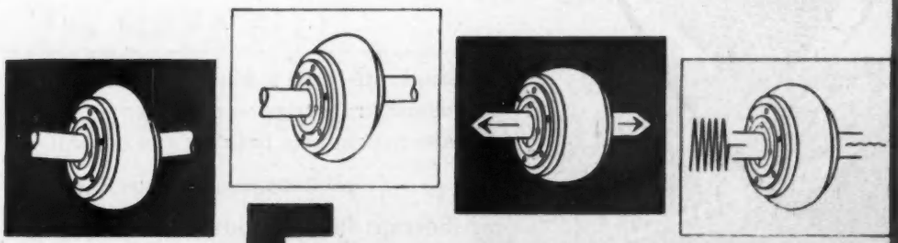

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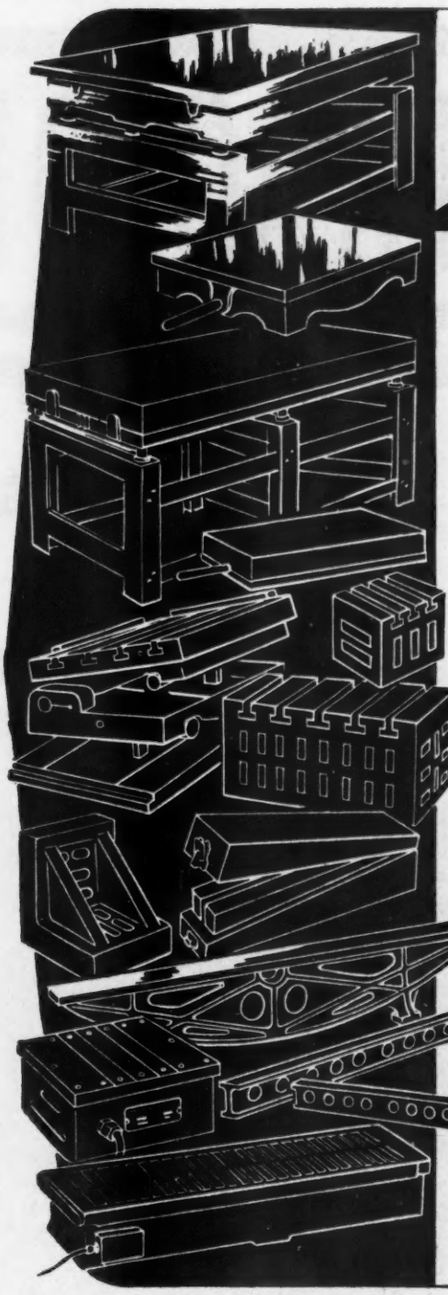

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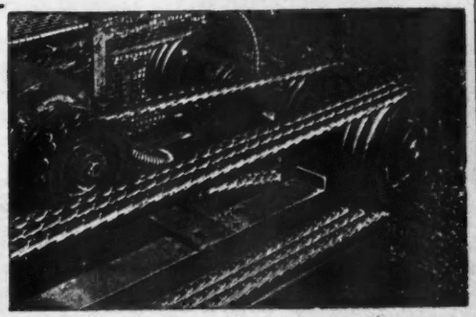

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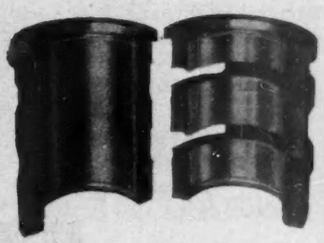

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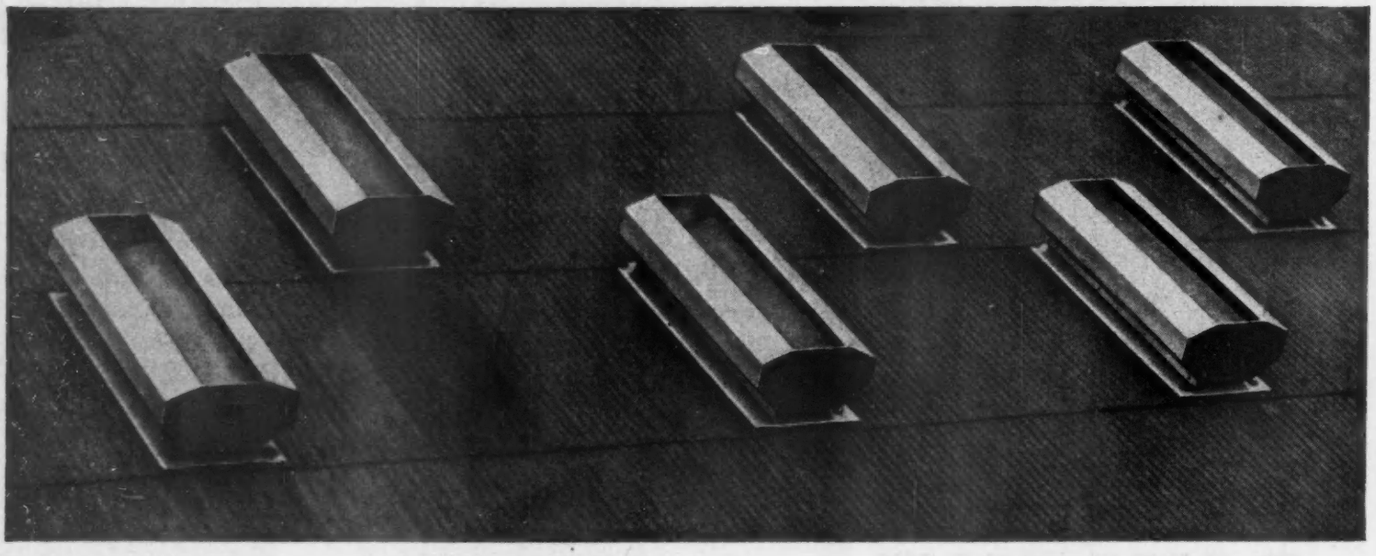

Anti-corrosive aluminium alloy cowling eliminates maintenance.

Baffle and adjustable dampers aerodynamically designed to eliminate turbulence—provide unrestricted outlet.

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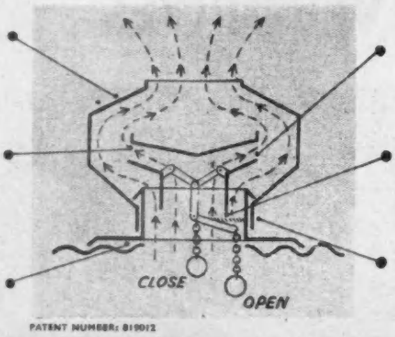

PATENT NUMBER: 819012

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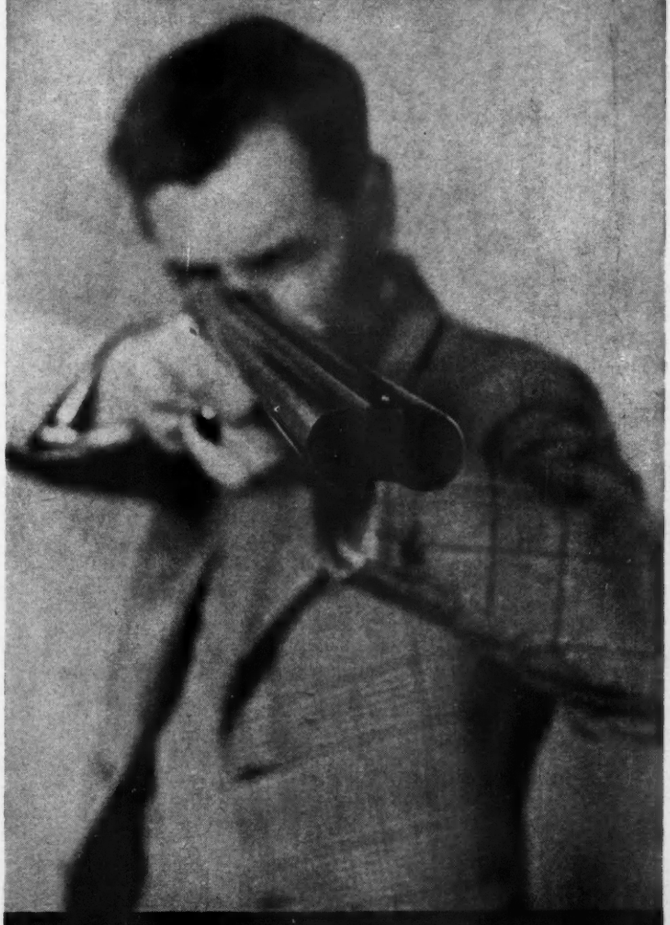
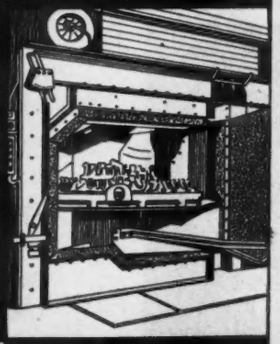


And they're talking about Linatex in factories all over the world. There's nothing like it for protection against wear and abrasion. That's why Linatex is used to cover tables and belts and to curtain the interior of shot-blast cabinets. Among its many users you'll find most of the big car manufacturers. Linatex, in taking the roughest treatment, reduces maintenance costs and increases output. What's more, shot consumption is reduced.



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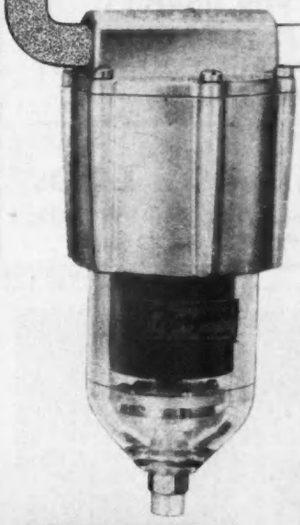

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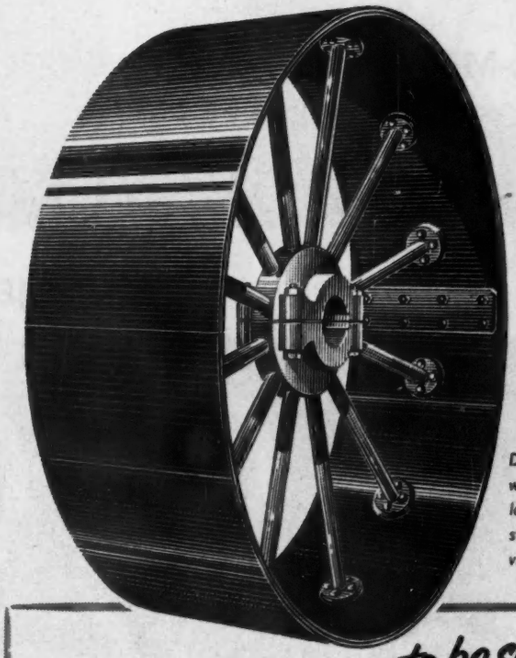

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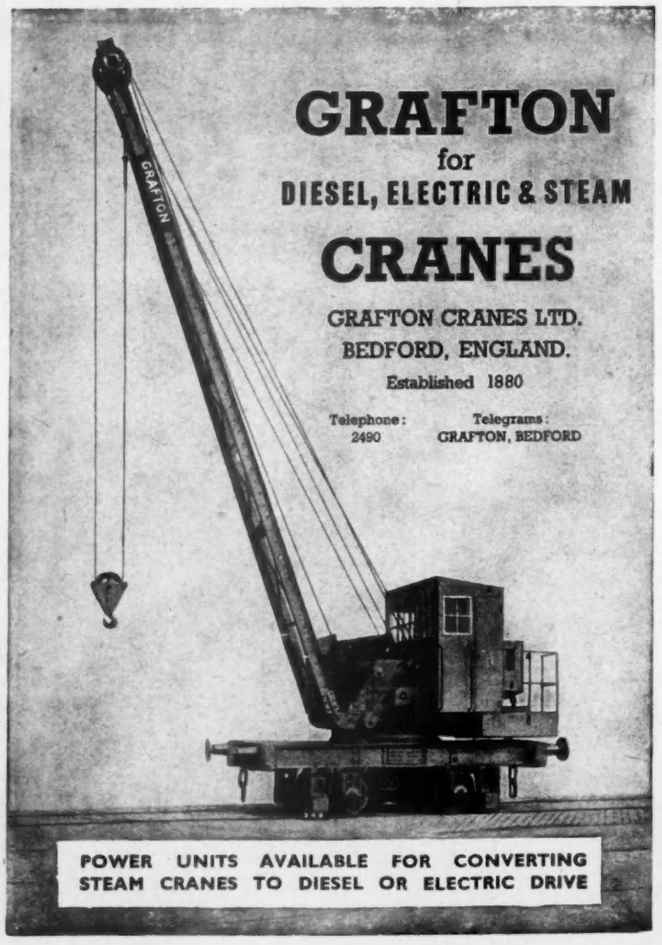

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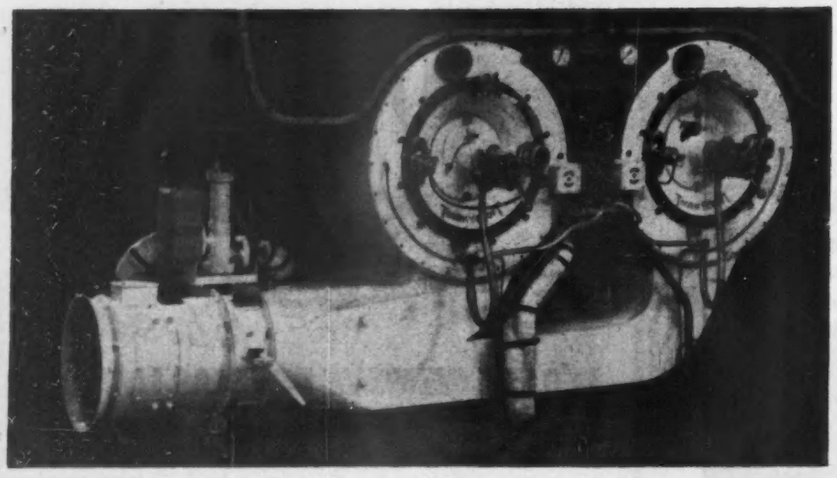

Thornycroft equipment has been chosen to illustrate pressure jet type burners fitted to an Economic boiler in the demonstration boiler house at Shell-Mex House.

These burners operate at an oil-pressure of 500 lbs. per sq. in. Recent installations include those at Glaxo Laboratories Ltd., several for the Ministry of Works, Selfridges and London Airport.

Illustrated left: the pressure jet type installation.

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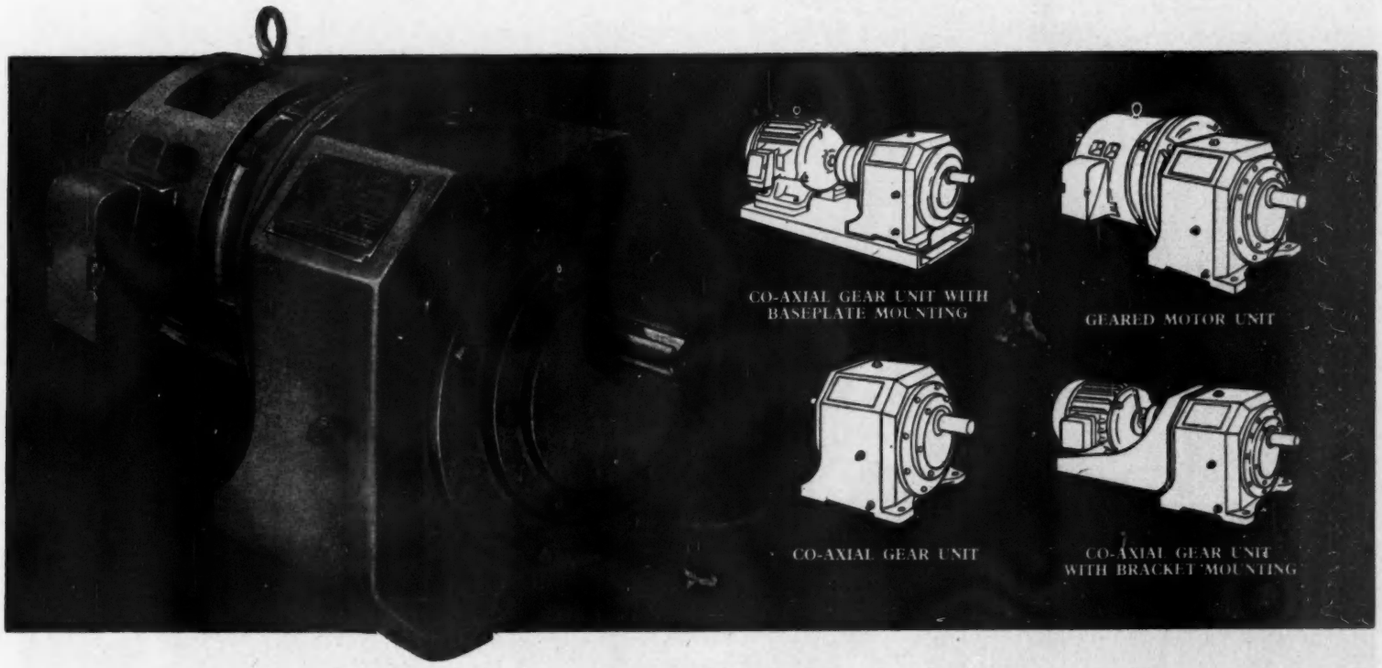
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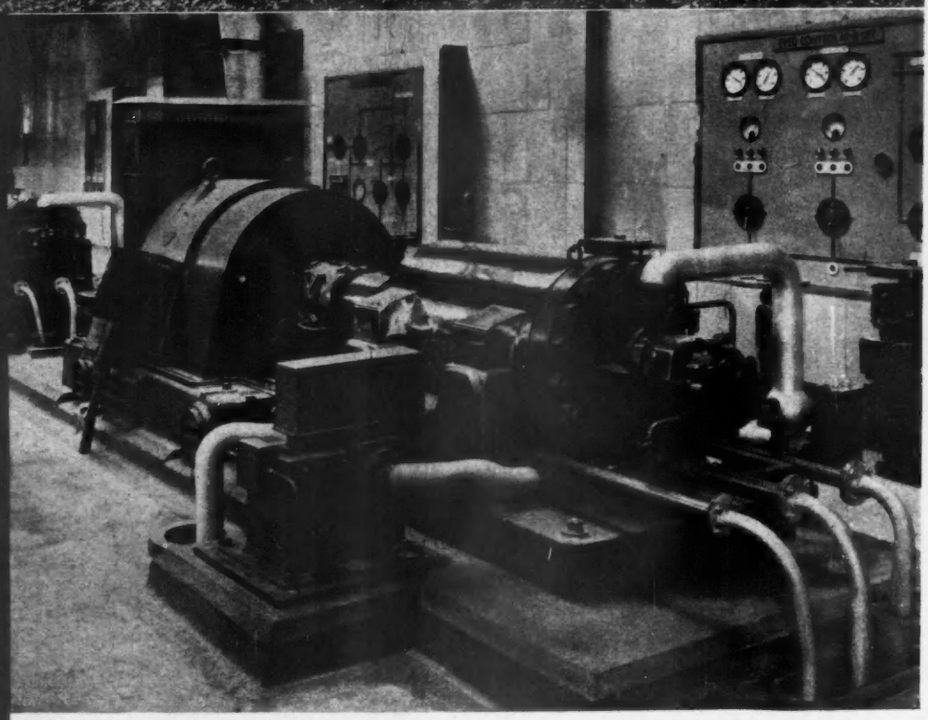

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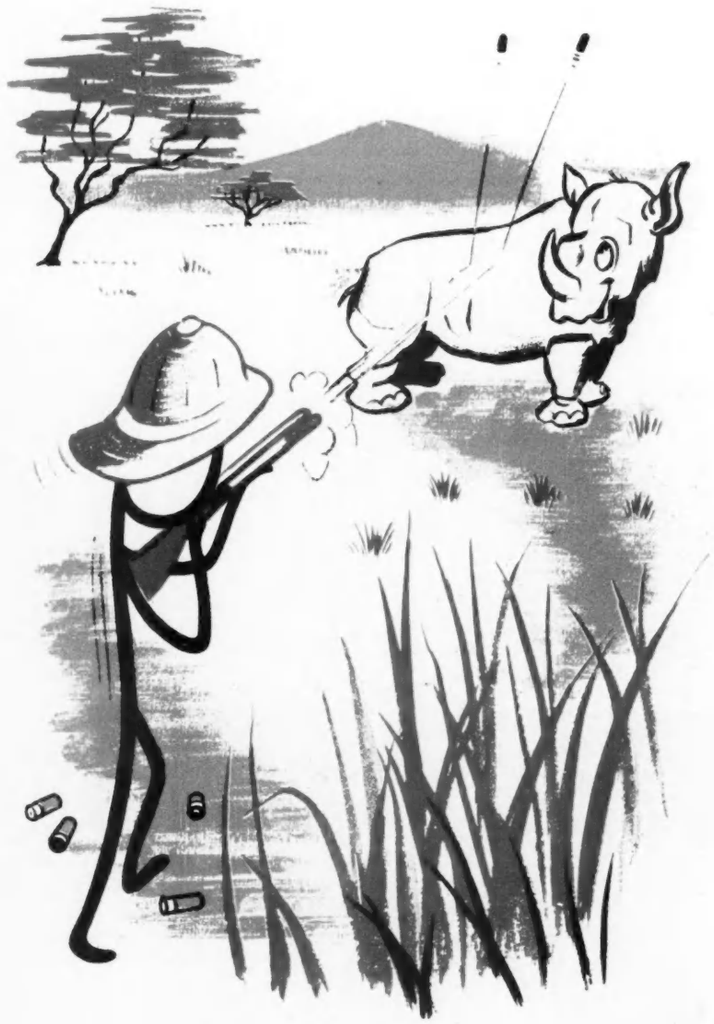
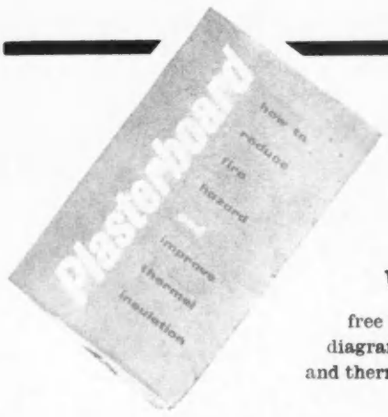


The thick-skinned type

The armour-plated rhino may shrug his shoulders, but some forms of fire bear no disregarding – the kind that annually cost the nation over eighty million pounds. Many of these fires occur in buildings where inflammable linings are used – which promote rather than inhibit the spread of fire. That's why far-sighted builders are making increasing use of plasterboard, which, due to the nature of its incombustible gypsum core, possesses Class 1 surfaces (B.S.476) both sides, *without requiring additional flame retardant treatment.* This at a cost in the region of only 4d. a square foot!



Write for

free brochure giving facts and diagrams concerning fire resistance and thermal insulation

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Its cost has in fact reverted to 1951 level.

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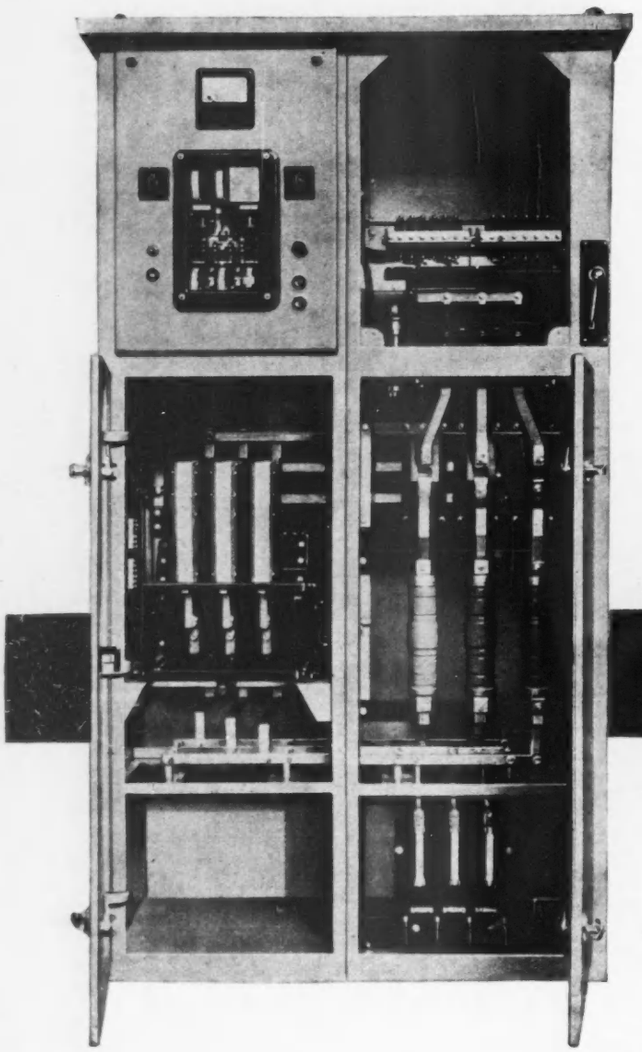
THE BELMOS 3·3 kV AIR-BREAK CONTACTOR STARTER

Rigorously tested in the Company's own research laboratory, the type K contactor starter is the latest product of the Belmos development team and continues the well-established Belmos tradition of good design and reliability. Suitable for the direct-on-line starting of 3·3 kV motors up to 600 h.p., it can be housed in a free-standing pillar or grouped with similar units to form a switchboard.



- ★ Air-break contactor rated at 150 amperes. Breaking capacity of 1,300 amperes at 3·3 kV, 0·25 power factor.
- ★ D.C. operating magnet supplied from 3,300/110 volt transformer within the pillar.
- ☆ Reversing or Earthing isolator, mechanically and electrically interlocked, with 12 auxiliary switches, a.c. or d.c.
- ★ Busbars designed to withstand 150 MVA for 3 seconds.
- ★ Optional earth leakage protection.
- ★ Comprehensive control arrangements, local and remote, with sequence interlocking and automatic sequence starting.
- ★ Provision for auxiliary services, such as brake protection, local lighting, etc.

the type K starter is fully described and illustrated in leaflet J 240 which is available on request.

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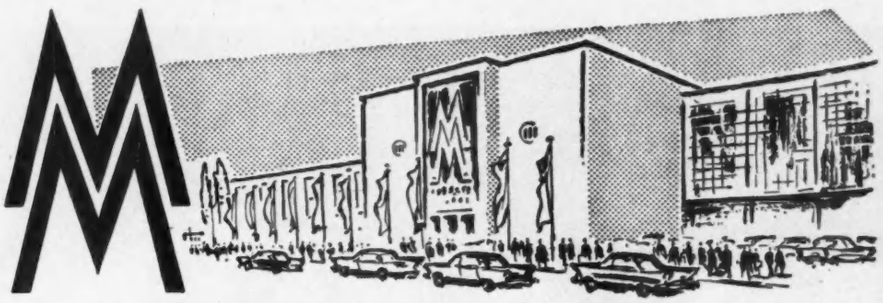

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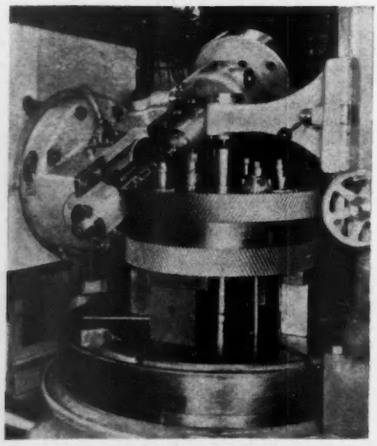

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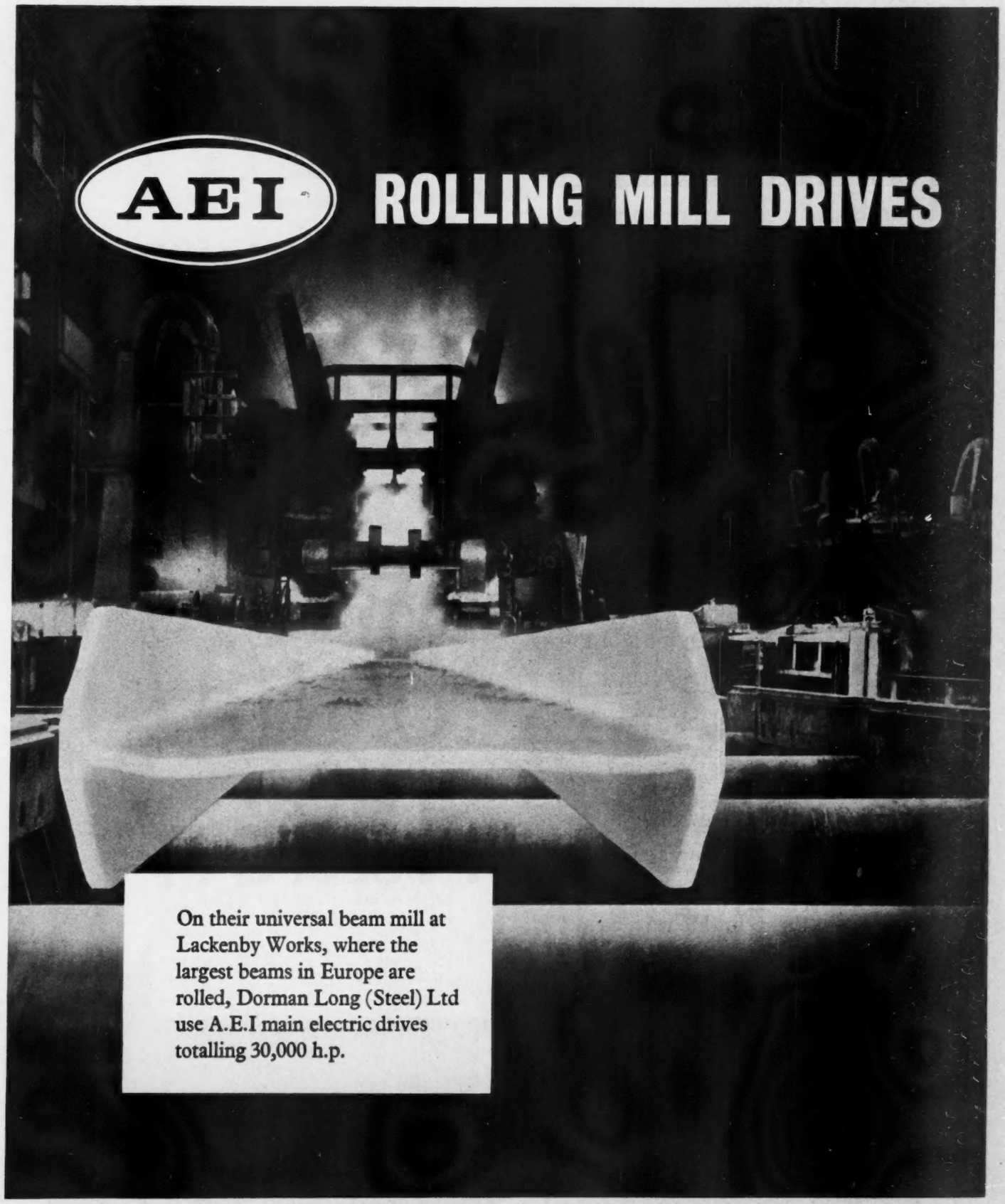
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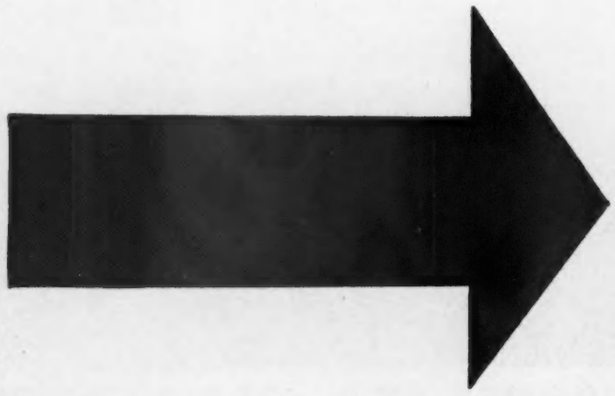
Steel's first 'Report to the Nation'

The British Iron and Steel Federation is adopting a new approach to the public in a series of advertisements in the national and provincial press entitled REPORT TO THE NATION. These advertisements, as they appear, will deal with current news of the steel industry. The first report is concerned, among other things, with the industry's production record and development plans; with some of the latest uses of steel; and with the social conditions of workers in a typical steel producing area. Future reports will explore other sides of the industry: the personalities running it; research activities; management training.

The first report has already appeared. It will be followed by others at intervals during the year, and almost everyone in the country will have a chance to see them. In this way, people can learn not only how a vital industry operates, but also how the prosperity and everyday life of the nation is bound up with that of Steel. The reports will be important, too, in helping those within Steel to know it better, and to realise they're part of an efficient, progressive and booming industry.



STEEL — NEW YE... TO THE N...

HOW MUCH STEEL IN 1960?

THE British steel industry may well produce about 24 million tons of steel in 1960—compared with 20 million tons last year.

Last year, and the year before, the steel industry spent some £100,000,000 on new plant and development—and raised its production capacity by about a *million* tons each year. This was done despite the fact that existing capacity, except in a few cases, was not being fully used.

Why this expansion, then? Is it an act of folly—or farsightedness?

It is simply an expression of confidence in Britain's future.

Apart from the sharp set-back around 1958, when the industry was working far below capacity, demand for steel has shown a steady upsurge since the war. Looking forwards, the industry has weighed forecasts made by its customers about their future demand.

As a result the industry believes that the trend of steel demand will continue to rise.

Planning ahead in Steel is a ticklish business. It means foreseeing future developments in the economic life of the nation, and the changing needs of steel consumers.

Among the thousands of steel-using firms the pattern of demand can change almost overnight. But planning, building and bringing into production a new steelworks inevitably takes years.

UNEXPECTED

A plant making rails cannot change over to production of sheet for cars.

Hence in the past two years, although the steel industry as a whole has not been working at full capacity, there have sometimes been shortages of steel sheet.

Why? The causes were an unexpectedly swift boom in cars - which took even the motor industry itself by surprise; rising sales of household goods like cookers and washing machines, and of electrical machinery; and a shift in demand from one kind of steel sheet to another.

£760 MILLION

Not even the wisest brains can predict, years ahead, every future shift in the pattern of demand. But Britain's steel industry has done remarkably well since the war in having the right plant ready at the right time.

Since the end of 1946, a sum of over £760,000,000 has been spent on development. The graphs show the crescendo of expansion in the last seven years; and also how the steel industry, far from lagging, has gone ahead faster than other manufacturing industries.

NEW MILLS

In the critical field of cold reduced sheet, production in 1959 was 13% up on 1958, and will rise again by perhaps as much as 20% in 1960. Further expansion at existing strip mills and construction of two new mills at Newport and Ravenscraig, work on which is being accelerated, will meet the likely demand for sheet and tinplate.

What of the other sections of the industry? Although hit by the recession, they have pressed on with expansion. The new Universal Beam Mill at Lackenby, best of its kind in the world, is in production - indeed, everywhere the nationwide programme of steel development is accelerating. At the lowest point (December, 1958) the industry was operating, on average, at about 70% of capacity. Now the rate is over 90% - of a greater capacity.

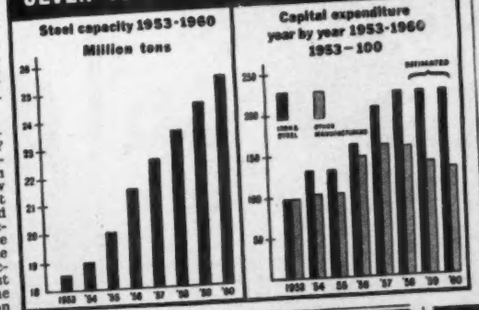
UP AND UP

Prospects are that there will still be some margin of capacity in 1960 in certain heavy steel products, as a result of continued slackness of demand from railways, coal mines, and shipbuilders. But demand for other types of steel is expected to rise still further.

Steel production in 1960 may therefore be between three and four million tons more than in 1959.

Continued modernisation and expansion - at a cost of over £100 million a year - will provide an efficient steel capacity of over 30 million tons by 1965, a sound basis for competing in world markets.

SEVEN YEARS OF STEADY PROGRESS



SIXTY KINDS OF STEEL ON T...

Steel takes these shock

THEY do brutal things to a car, down at Nuneaton, on the proving grounds of the Motor Industry Research Association. And every time they test a car, sixty different kinds of steel are on trial. That's how many there are in a modern car.

One of the tortures have devised consist pavé track made of stone blocks, set angles, with plen pot-holes. They li drive cars across it.

And what bears brunt of this savage

Fifty

New life in the Valleys

BY TREVOR EVANS

THE "black years" of the 'twenties and 'thirties are not yet forgotten in South Wales. So it was with deep misgivings that I went back to the village where I grew up.

I was never so surprised in my life. I rubbed my eyes, thinking for a moment that I had driven into the wr...

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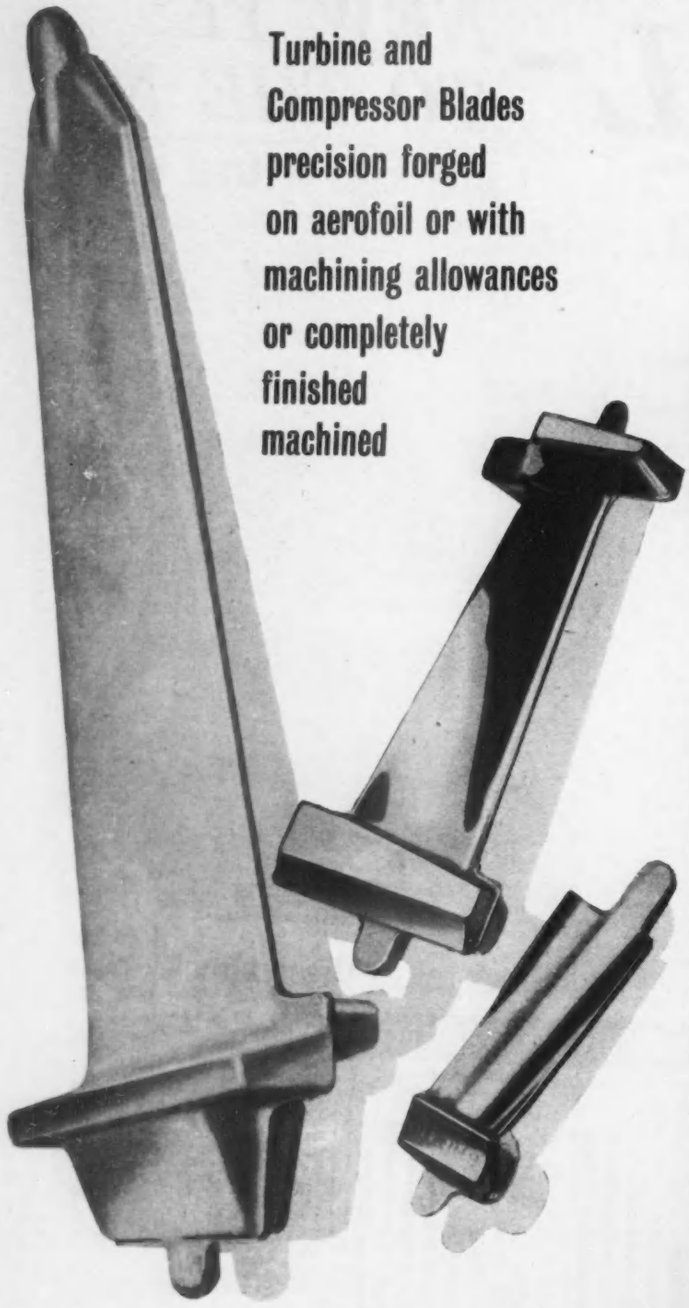

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Photo by courtesy of B.I.C.C. and British Railways.

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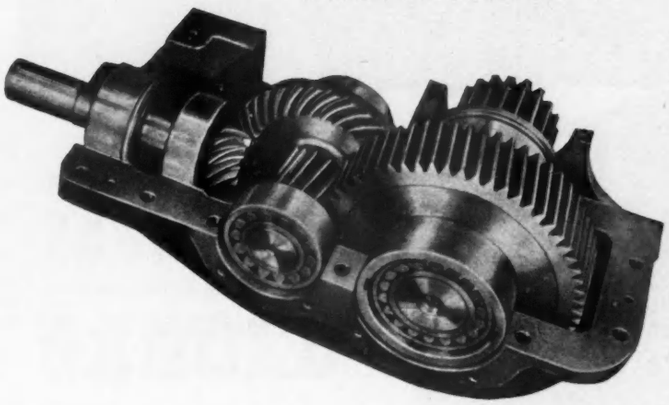

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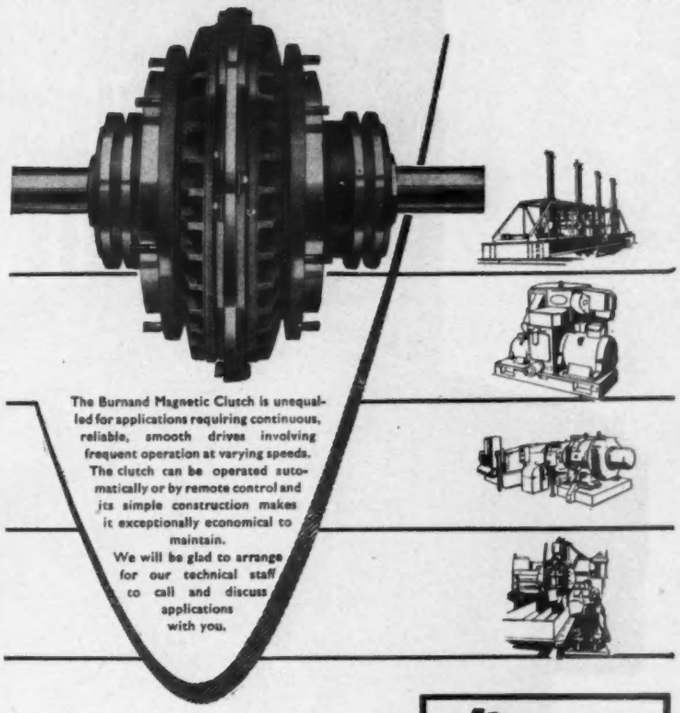

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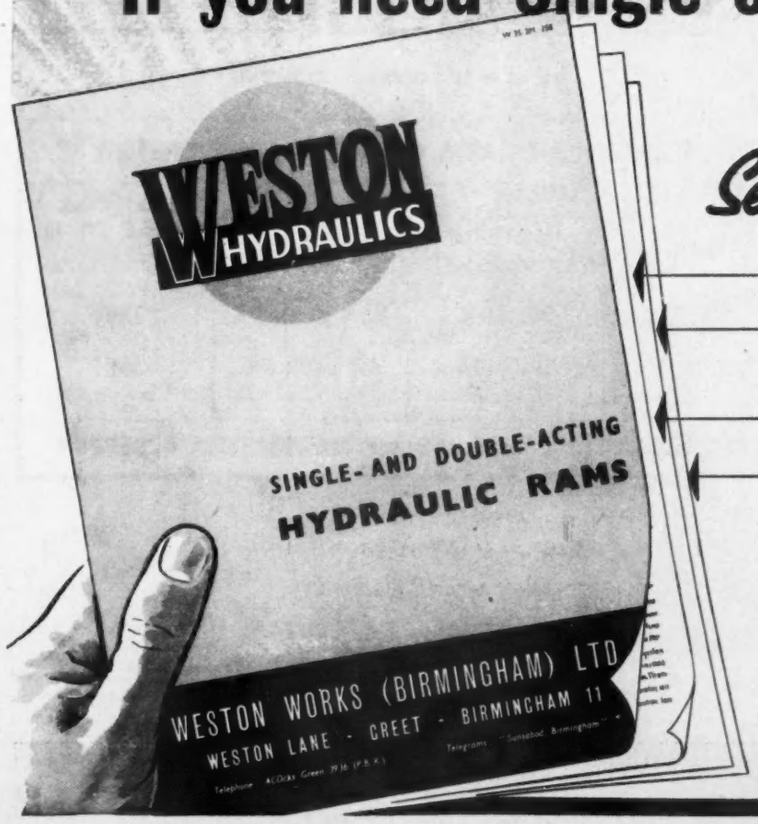

- offering a wide standard range of hydraulic rams.
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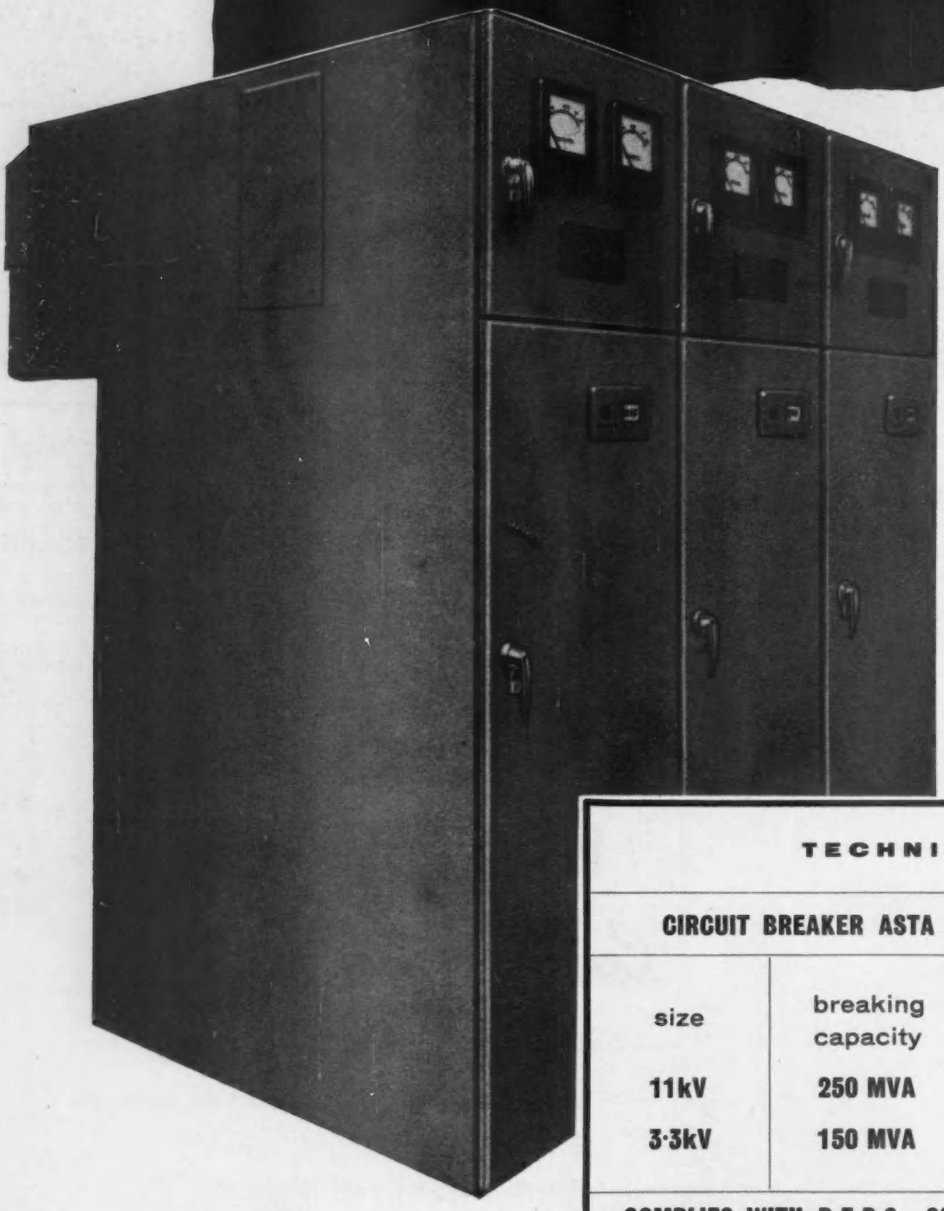

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TECHNICAL DATA

CIRCUIT BREAKER ASTA CERTIFIED TO B.S. 116:1952

size	breaking capacity	making capacity	ASTA certificate
11kV	250 MVA	33·4 peak kA	3990
3·3kV	150 MVA	67 peak kA	3991

COMPLIES WITH B.E.B.S.—S2 and THE 250 MVA ADDENDUM

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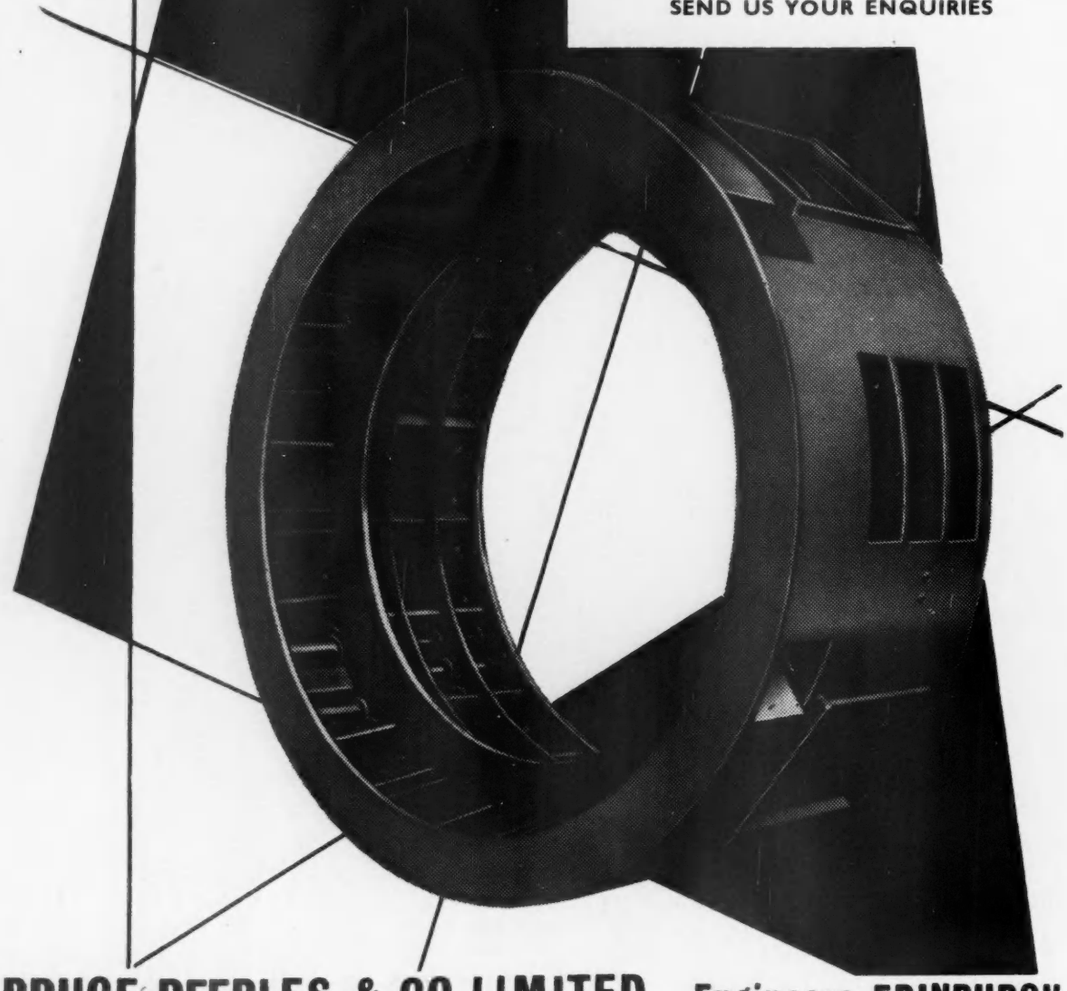

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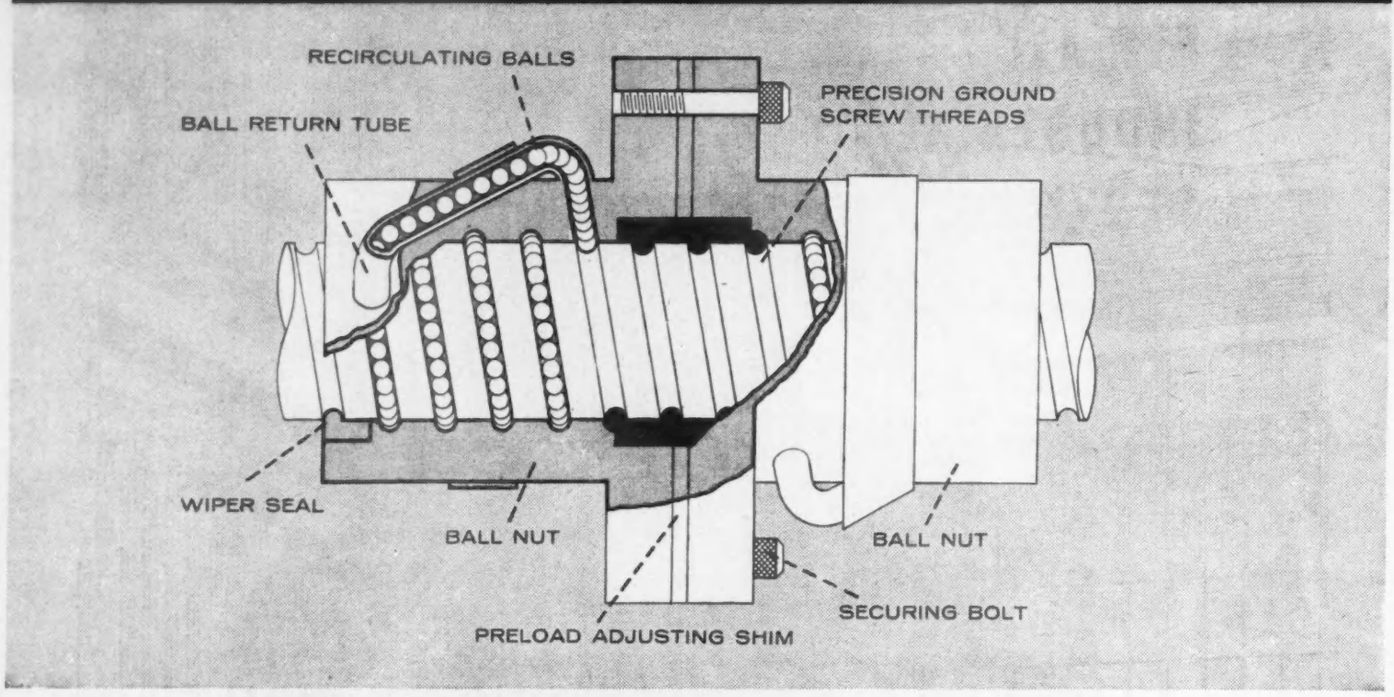

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Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of —52° C to 400° C without lubrication, and up to 170° C when lubricated.

Machined and ground to the highest standards of precision engineering Beaver pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

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J. B. STARKY, SALES MANAGER (BEAVER PRODUCTS DIVISION), BRISTOL SIDDELEY ENGINES LIMITED, PO BOX 17, COVENTRY, ENGLAND.

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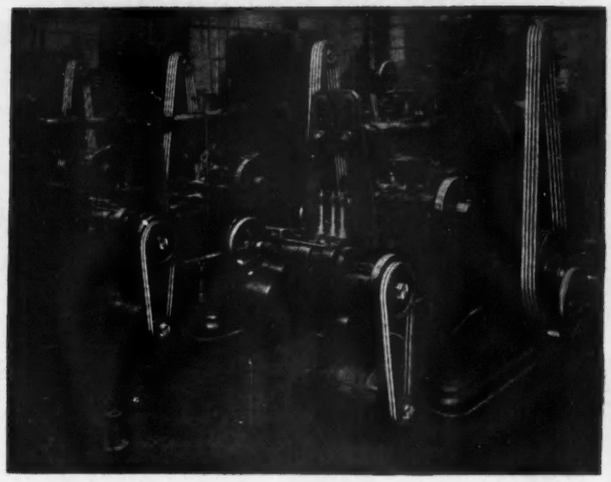

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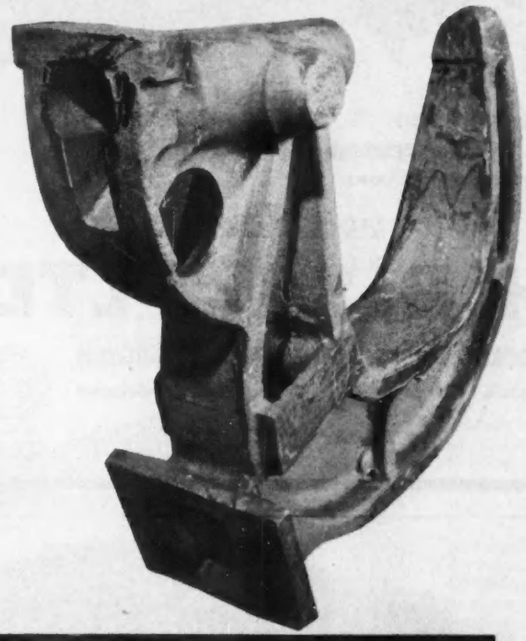

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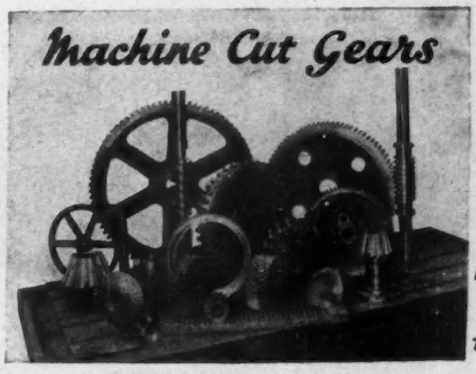

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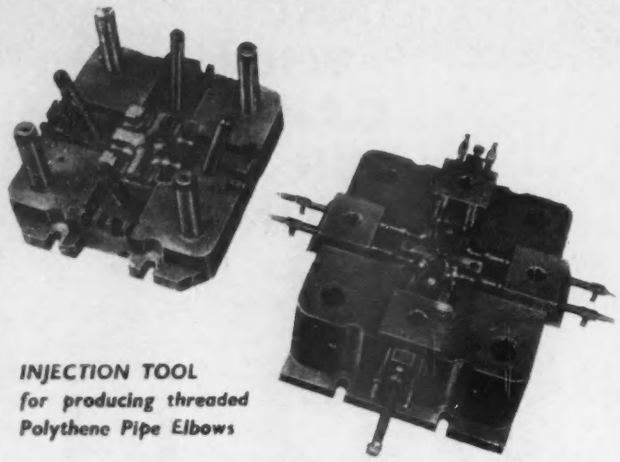

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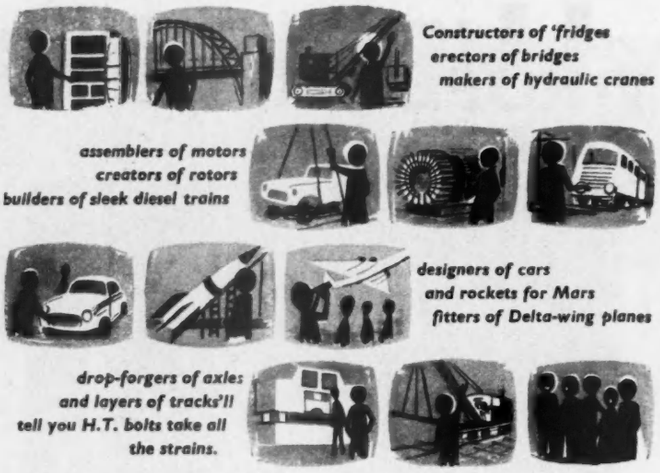

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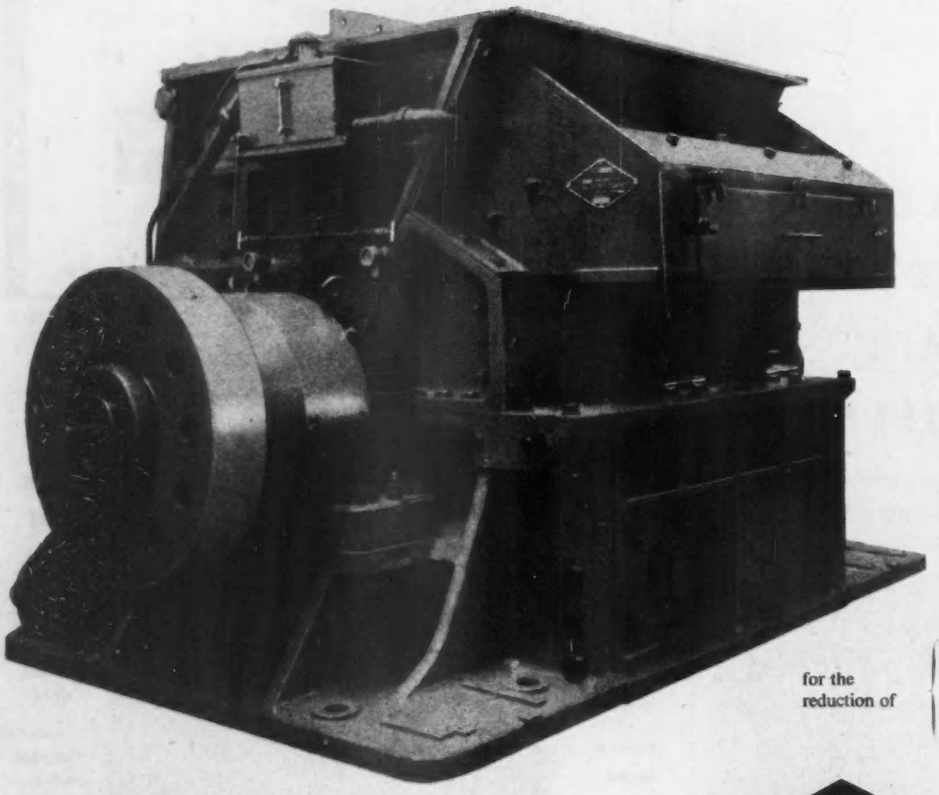

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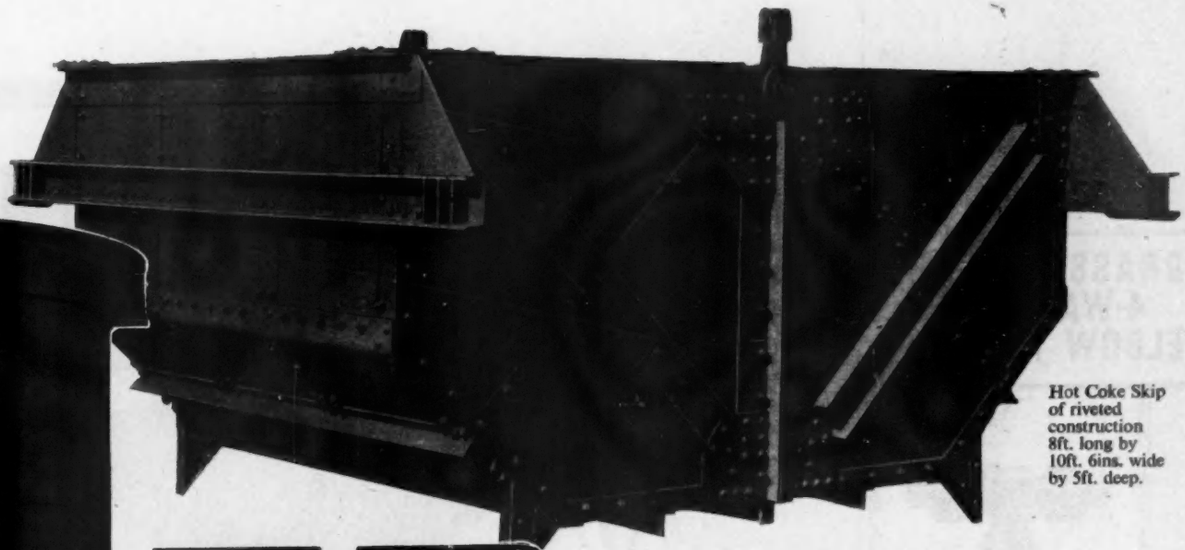

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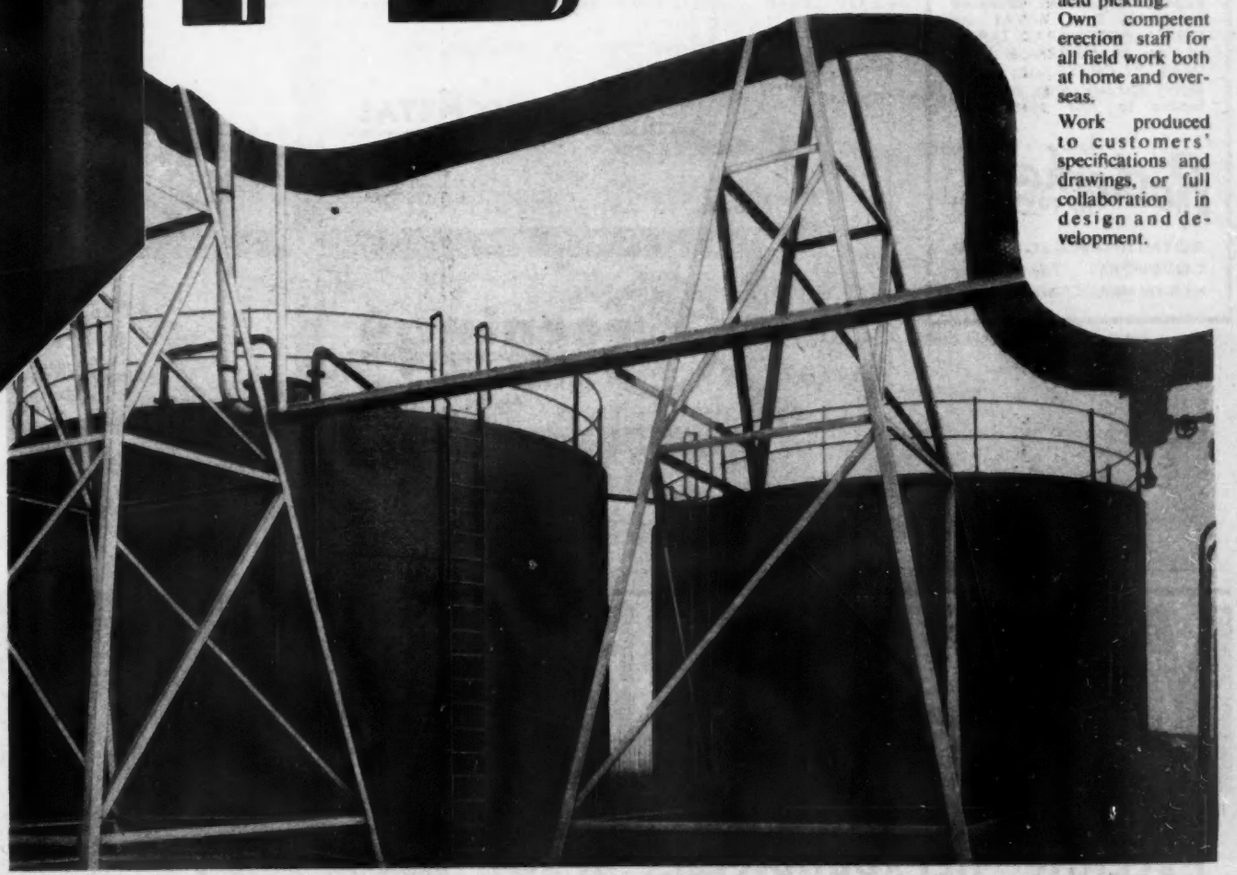

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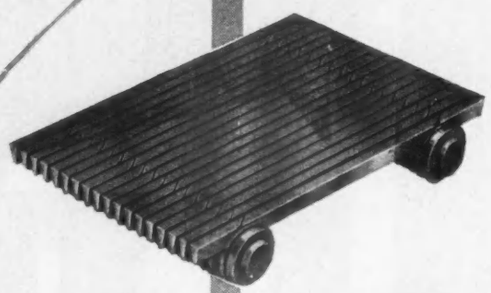

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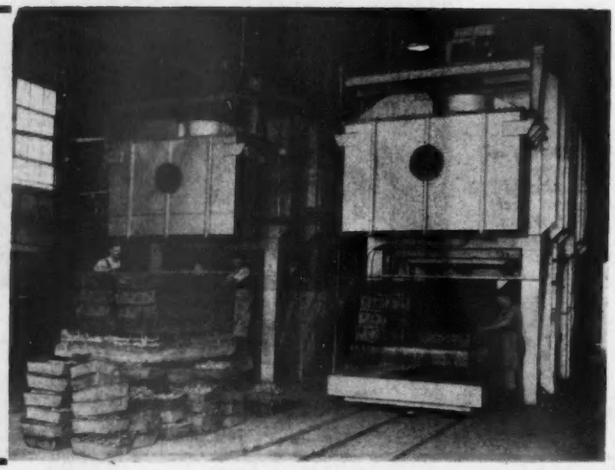

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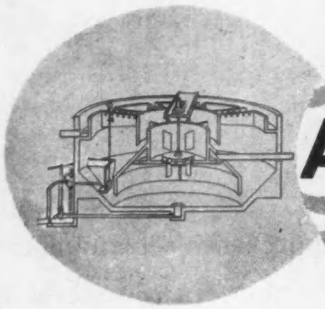

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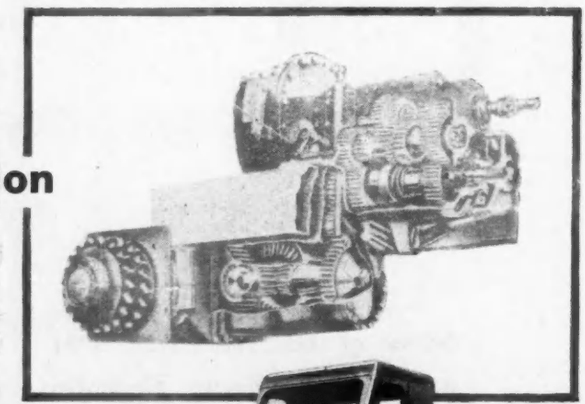

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2½" dia.	Oil quenched 830°C. tempered 590°C.	75·2	78·8	17	44
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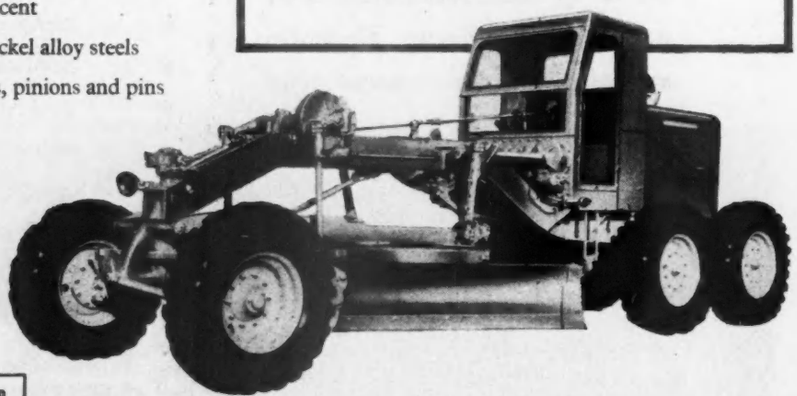

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THE ENGINEER

No. 5430 FEBRUARY 19, 1960 VOL. 209

RAILWAY UN-SETTLEMENT

At a late hour last Friday, the country learned that the strike ordered by the National Union of Railwaymen to begin at midnight last Sunday had been called off. That announcement came after two days of talks in which the Minister of Labour and his industrial commissioner, the British Transport Commission, the three railway unions and the Trades Union Congress had all participated. Those talks culminated in an offer by the British Transport Commission to grant an "interim increase" of 5 per cent on existing rates of railway wages. This increase is back-dated to January 11 in fulfilment of an undertaking given recently by the British Transport Commission to make retrospective to that day any interim negotiated increase following the receipt of the Guillebaud committee's report. The 5 per cent offer was accepted unanimously by the N.U.R. executive, and the two other railway unions, namely, the Associated Society of Locomotive Engineers and Firemen and the Transport Salaried Staffs Association, were willing to approve, once they felt assured that it would not prejudice full consideration of the thorny subject of differentials. Thus, the threatened railway stoppage was averted and the train travelling public and industry were spared the inconvenience and the additional unwarranted expenditure which would have been incurred.

But "an event has happened, upon which it is difficult to speak and impossible to keep silent." This week there has been increasing realisation of the fact that, whilst it is a good thing the railway strike was called off, the future of railway wages and, indeed, the future of railway finances remain hazardous. There is no really satisfactory settlement in sight. In our issue of January 22 we explained that the last railway wage increase was made on June 30, 1958. It was of the order of 3 per cent, bringing, for example, the basic weekly wage of porters (with three years' service) to £7 16s., of signalmen (seven classes) to between £8 13s. 6d. and £11 3s. 6d., and of engine drivers (with three years' service) to £11 9s. In the salaried grades, Class 1 senior male clerks receive between £707 and £753 a year and Class 1 station masters between £717 and £763. In considering these sample figures, it is, of course, proper to bear in mind the value of "allowances in kind," such as uniform and concessionary travel. Even so, there has been the widespread feeling that, compared with the general level of wages and salaries, railway pay ought to be improved despite the fact that the British Transport Commission's finances could not stand an increase! After the last increase was made, the three railway unions agreed to the appointment by the Commission of an independent committee to make a detailed examination of the wage and salary structure. That committee, under the chairmanship of Mr. C. W. Guillebaud, started work in the autumn of 1958, and the three unions undertook not to make any further pay claims until the results of the committee's investigation were available. The committee's task has undoubtedly been an arduous and complex one and some weeks ago it was announced that its report could not be completed until April. Before that announcement was made, however, the N.U.R., probably because of pressure exerted by sections of its membership, had formulated a claim for a substantial wage increase. It was rejected in the first two stages of negotiation and before it had been considered by the third and final stage, the arbitration tribunal, pressure was intensified for an immediate interim increase in advance of the Guillebaud committee's report. The only possible response from the British Transport Commission was that it could not depart from an agreement "at the request of one party to it only." As already mentioned, the Commission had promised to back-date to January 11 any negotiated interim increase arising from the Guillebaud report. Then came the N.U.R. declaration that "it had no alternative" but to instruct all its members to withdraw their labour as from midnight on February 14. The N.U.R. was not influenced by Mr. Guillebaud's subsequent promise to bring his report forward to the week beginning February 29 and an attempt by the T.U.C. general purposes committee to find a basis for agreement met with no success. Very possibly, we think, once the N.U.R. executive had called for a strike it no longer had the power to call it off, so strongly did railwaymen feel they were underpaid! On Wednesday of last week the Minister of Labour intervened and, with the help of his industrial commissioner, succeeded in bringing together all the parties concerned in the dispute. The outcome of that intervention was the offer of the 5 per cent increase, an offer which Sir Brian Robertson, on behalf of the British Transport Commission, was evidently prompted by the Government to make, after Mr. Guillebaud had agreed that the extent of the increase was "containable" within the framework of his forthcoming report.

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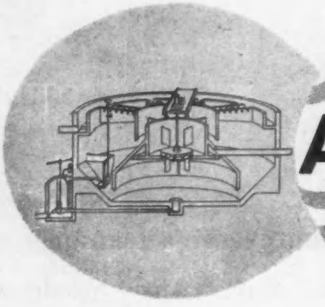

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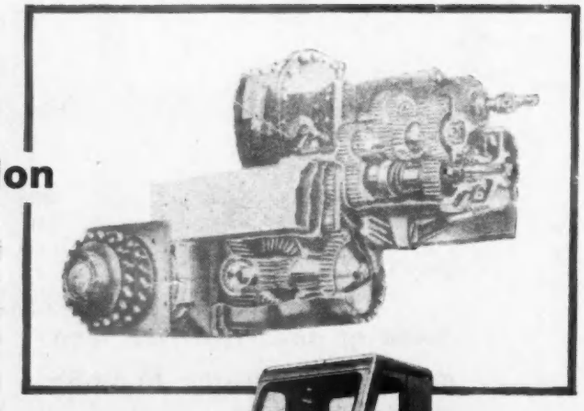

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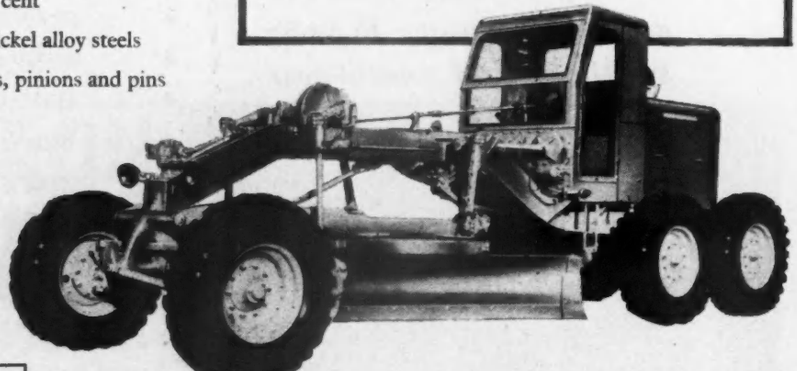

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In less than a fortnight, the long-awaited Guillebaud report will indicate how much more is required to deal fairly with the wage differentials between skilled and unskilled railway staff and thus suggest a way of putting the whole of the railway wage structure on to a sounder footing. That, however, is something that will not be achieved merely by waiting for the completion of the railway modernisation plan and for the more efficient services that may then be expected. Serious decisions about the British Transport Commission's financial structure will have to be taken. They may well involve, among other things, renewed consideration of the railway modernisation plan. Just how much, for example, of the existing railway system will it really be economic to retain and operate in the future ? The urgency of these matters is emphasised by the way in which the railwaymen have sought and secured their interim wage increase.

GOVERNMENT AND AIRCRAFT

Quite hard on the heels of the news about the grouping of British aircraft firms Mr. Sandys announced last Monday some details of the ways in which the Government intends to help the British aircraft industry to re-orientate itself towards the production in the future principally of civil, instead of military, aircraft. Of the five groups of aircraft firms which have been formed two are fixed-wing aircraft makers, one specialises on helicopters, and two are engine builders. The general intention of the Government, it appears, is to concentrate orders on these groups, though firms not in the groups are not to be left out in the cold if " specialised requirements " or " public policy " make it desirable to help them. The Government will, also, " where appropriate " provide increased support (whatever that may imply) for promising civil aircraft projects and aero-engines ; and it intends to continue " for the present " a substantial programme of aeronautical research. The Government may contribute towards the development, tooling, or other initial costs of launching a new type of civil aircraft, and in order to enable earlier delivery dates to be offered it may also take a share in the risks involved in producing a limited number of aircraft beyond those for which firm orders have been received. It may also be prepared to contribute towards the costs of proving a new type of civil aircraft and of introducing it into service. Suitable arrangements will be made for the Government to participate in the proceeds of sales. Notably, in relation to much criticism made in the past, the Government is to seek to harmonise the characteristics of military and civil types of transport aircraft.

It remains to be discovered by experience how much real change in Government policy is implied by Mr. Sandys' statement. But, whatever change there may be in policy, not very much can now be done to alter what the more immediate future has in store for the industry. Prosperity, or the reverse, is largely dependent upon the success in world markets of such aircraft as the " Vanguard," " Herald," and " Argosy," the VC.10 and the D.H. 121, the " Rotodyne," and others already in or approaching the production stage. But greater rapidity in reaching decisions and firmer immediate resultant action might help appreciably in certain ways. It is upon the slightly more distant future that the present changes must have the greater impact. The particularly desirable change is that there should be greater speed in bringing newer developments to fruition. The really desirable thing, of course, would be to make a major break-through so as to produce an aircraft or an engine (or both) far more advanced than anything with which it had to compete. But that is seldom possible, if only because it means entering upon and attaining unexpectedly early success within a research programme of so advanced a character that no time-table can possibly be laid down for its completion. The more practicable process, not, however, to be regarded as an alternative, to the consequent exclusion of advanced research, is to look less far into the future, to foresee what research and other work will have to be done towards achieving a clearly attainable end and concentrate men and money on a project with the intention of having an actual craft or engine in production well before anyone else has got so far. May we hope that Mr. Sandys' statement implies that that is one of the policies the Government hopes to encourage ?

Certainly one thing is clear. The whole set-up of aircraft production in this country has experienced a major change. On the Government side a single Ministry of Aviation has been created and the little-lamented Ministry of Supply has disappeared ; on the industrial side five major groupings have been created. Not without some nagging fears, we hope the reorganisation will improve the prospects of prosperity for the industry in what is certain to prove a highly competitive future.

THE BARTON BRIDGE ACCIDENT

There can be little doubt about the reasons why the four girders at Barton Bridge toppled over on December 30, after the evidence given at the inquest on the two men who were killed. A brief report appears on page 306 of this issue, from which the tragic simplicity of the situation is clear. Two general issues arise, however, from the jury's recommendations, namely " that a fully-qualified technical and/or professional co-ordination officer should be appointed for such contracts by the main contractor ; and legislation should be introduced to ensure the safety of all concerned with this type of work."

The need for efficient professional supervision is, of course, basic to all constructional works, and is a fundamental principle behind all the training, codes of practice and ethics of professional conduct recommended by the Institution of Civil Engineers and similar bodies. In this case the situation was complicated by the change of sub-contractor and responsibilities were evidently not clearly defined over the critical period in which the accident occurred and prior to it " the effective control of site labour " was in doubt. Inquiries into accidents such as this one reveal that there is something in common amongst the situations which lead up to them. In 1958 there was a much worse bridge accident in Vancouver. The two British engineers who served on the panel of inquiry gave as the first of a list of " lessons " learned from the disaster " the avoidance of structures liable to instability and the early teaching of the possibility of such instability." They also stressed " the advantages derived from the consideration by the engineer of the contractor's proposals for falsework, and the resident engineer's oversight of temporary works in progress with regard both to the saving of delays in completion (which almost inevitably arise from such accidents) and to the safety of men engaged on construction." " Small and simple mistakes," they concluded, " can lead to big catastrophes and no opportunity should be missed in arranging for the check and recheck of the design and detailing of an engineering structure for its ability to perform its intended duty " (see *Proceedings*, I.C.E., April, 1959). It may be questioned whether the appointment of such an officer as the jury recommended is really germane. What is important, in the general case, is the level of professional supervision throughout the work as emphasised by

Messrs. Freeman and Otter in the words abstracted above.

The second issue asserts the desirability of safety regulations for civil engineering works. Strangely enough, this class of work is not covered by existing regulations ; the Factory Acts contain some sections relating to " construction," but they are not very positive. However, regulations could be introduced under the Factory Acts, and in fact some attention has been given to this over the past few years and one class of construction, namely, working in compressed air, has recently been covered by new regulations introduced in 1958. The civil engineering industry appears, from such incomplete statistics as are compiled for it, to be one of the more dangerous industries, but not more dangerous than, for instance, coal mining. The most recent report of the Chief Inspector of Factories (for 1958) lists fifty-one fatalities during the year under the heading of " Works of Engineering Construction " and a further 207 under " Building Operations." The total number of accidents in the year were, respectively, 2329 and 15,017 in these two categories. There seems to be a general desire in the civil engineering industry that fairly comprehensive safety regulations should be introduced, one suggested line of approach being the extension of building regulations to make them more universally applicable. The Barton bridge accident may well accelerate this trend, for apparently a statement is expected from the Minister of Labour soon. It is undeniable that the character of civil engineering works is such that hazard cannot be eliminated, but a rate of fatalities of about one a week seems a high price to pay, even for the vast benefits which these works bring with them. The Federation of Civil Engineering Contractors has drawn attention, since the Barton bridge accident, to the safety training which it introduced last year. There is clearly scope for much extension and intensification of work of this kind, which, backed by well-conceived regulations and the availability of fairly precise statistical data on the frequency and causation of accidents, would bring about no little improvement.

DEFENCE

The White Paper on Defence for 1960–61 was published very shortly before we went to press and we intend to reserve considered comment until next week. However, some points are worthy of immediate notice. The Estimates are higher by nearly £116 million than they were last year ; but owing to the inclusion this time of certain items which used to appear elsewhere in the Government's accounts the real increase is within the region of £90,000,000. There is some evidence that the emphasis in defence thinking is shifting. Clearly, for example, the impossibility of concealing fixed rocket-firing sites has become better recognised together with the vulnerability of such sites to ballistic missile attack. As a consequence the possibilities of launching ballistic missiles from submarines or aircraft are to be more fully investigated than hitherto. For many months, readers will remember, we have advocated their launching in some way from ships. This change in emphasis throws some doubt on the eventual future of the " Blue Streak " rocket still under development, which is intended for launching from land-based sites. But work on it appears certain to continue at present. We learn that the U.S.A. is to provide a ballistic missile warning system for Britain. There is no suggestion yet of any real expansion of the Royal Navy ; but it is expected that an order will be placed during the year for the first all-British nuclear submarine. The " Dreadnought," a submarine now building, it will be recalled, is to be equipped with an American nuclear power plant. On land, the White Paper expresses a great deal of confidence in a new main battle tank under development which " promises to be as outstanding in its class . . . as the 'Centurion.' " In references to military air transport we note that a second squadron of " Britannia's " will come into service during the year, that deliveries of the " Britannic " and of the " Argosy " when they begin will " fortify " the tactical transport force, and that a contract has been placed for the development of the " Rotodyne."

HOOK ROAD UNDERPASS

The opening last week of a two-level junction on the Kingston by-pass is of special note as a commentary on the present obsolescence of London's road system. With the exception of the Chiswick flyover on the new Cromwell Road extension, this underpass is the only major road junction in the London area that can lay any claim at all to adequacy. Leaving aside the desirability of a metropolitan network of high-speed roads approaching motorway standards, even a modest appraisal of the needs of London's roads must take account of the well-preached and long established fact that it is the capacity of the junctions which limits traffic flow. If nothing at all could be done to the roads—an assumption which few would accept anyway—the very least that could be expected would be redesign at critical road junctions. The Hook Road underpass took a year and a half to build. It was not a large job, as civil engineering schemes go, but the site restrictions imposed by neighbouring properties and by keeping traffic on the move were quite onerous. But although work was started in September, 1958, the scheme was actually prepared in 1954, so it took above three times as long to reach the constructional stage as it took to build it.

The Engineer—100 Years Ago (FEBRUARY 17, 1860)

" LOCOMOTIVE ENGINES "

" As our railway engines are now constructed, from 30 tons to 40 tons are carried to develope an amount of adhesion which from 12 tons to 20 tons weight ought to give. The rest is literally and actually dead weight. Of all railway rolling stock, locomotives and tenders cost the most for moving about. The moving friction of a locomotive, with its pistons, valves, double journals, guides, pumps, eccentrics, etc, is far more than the mere rolling resistance of the same weight of carriages. And from the want of strict economy in generating and working the steam we are still compelled to provide and drag about a lumbering tender, just to carry a ton or so of coal and 5 tons or 6 tons of water. Of the entire average weight of a passenger train upon an English railway, the engine and tender form about one-half ; and the power expended in driving them, whether their mere working friction be regarded alone, or together with their gravity upon inclines, is more than one-half of the total power exerted. We should say, at least 12 lb. of fuel are expended on the average, per train mile, in getting the engine and tender over the line. Of the wear and tear produced upon the line, the engines and tenders may be safely considered to produce about one-half ; since they exert very much more destructive effects in proportion to their weight, than the rest of the rolling stock. The weight of an engine is concentrated generally upon six points only, 6 tons being a common, and 7 tons or 8 tons an occasional weight on a single driving wheel".

Some High Spots in Thermal Power Generation

By B. WOOD, M.A.*

(No. II—*Concluded from page* 253, *February* 12)

This paper, given before the annual meeting of the Engineering Institute of Canada, Quebec City, May, 1958, contains a topical survey of developments in large steam power plant with comments on highest points achieved in turbines and boilers at present ordered. Comments are made on trends, limitations, prospects and economic aspects. Stress is laid on the importance of choice of speed of turbines as affecting exhaust arrangement in view of the more easily won gains at the low temperature end of the cycle. A world list of outstanding units in point of size, temperature or pressure is given. Mention is also made of gas turbines.

THERE are two non-technical factors which seem sometimes to influence turbine design unduly. One is the desire on the part of both maker and the purchaser to establish a record. Thus the unit size may have to be larger than that installed by someone else. The second is the use of the highest speed. Manufacturers have in the past tended to urge the use of the highest speed possible on the ground that this led to a cheaper and lighter machine. It was not always true, when sizes were smaller, that the best speed for the manufacturer was best for the customer and with the larger sizes now in use the choice merits very careful consideration. There is, for instance, no great difference in weight per kilovolt-ampere between two-pole and four-pole alternators. The real advantage of high speed in the turbine at the high-pressure end becomes a disadvantage in the low-pressure part. Hence a two-shaft 3600/1800 r.p.m. design has advantages both ways.

Briefly the choice available at 60 (or 50) c/s is as follows:

Single-shaft generally with two or three exhausts at 3600 r.p.m. up to about 200MW on good vacuum or 275MW on poor vacuum. (In Europe, with three or four exhausts, at 3000 r.p.m. up to 300MW.) (Fig. 3).

Two-shaft 150MW–500MW with l.p. line having two (or more) exhausts at 1800 r.p.m. and h.p./i.p. line at 3600 r.p.m. (Fig. 2).

Two-shaft 150MW–500MW with four or six exhausts at 3600/3600 r.p.m. arranged symmetrically (Fig. 4). (In England corresponding 550MW six or eight exhaust machine at 3000/3000 r.p.m.)

In the U.S.A. the list price of large machines of the same exhaust area and steam conditions is substantially the same for either 3600/3600 r.p.m. or 3600/1800 r.p.m. machines. (Fig. 7, page 294.) The 3600/1800 r.p.m. machine will, however, show an appreciably better heat rate (by order of 1 per cent at 350MW and 1in back pressure) attributable partly to easier aerodynamic conditions on l.p. blades. Its l.p. portion runs at lower stresses and the machines may be shorter and hence cheaper to house. The type is represented by a large number of sets of 150MW, 200MW, 300MW and up to 500MW and until recently appeared to be the main line of development.

The third type is exemplified by the Breed machine of 450MW with six exhausts, and several earlier machines with four exhausts. The first of this class was a 40MW reheat set installed at Barking " A " in 1922, which had four exhausts disposed on two equal 3000 r.p.m. lines. The attraction to the manufacturer appears to be the standardisation of manufacturing resulting. It is not clear what is the advantage to the customer compared with a 3600/1800 r.p.m. design of equal exhaust. It should, however, be mentioned that large 1800 r.p.m. rotors cannot be transported fully bladed. They must be dismantled by removing either wheels or blades after shop testing and be reassembled on site. They also entail the provision of large machine tools and tend to compel the designer to adopt a built-up rotor, because of the otherwise excessive size of a solid forging. At present, however, fashion has swung in favour of building up, and it may be assumed that development at 1800 r.p.m. will continue.

Present exhaust limits at 60 c/s. are given in Table IX.

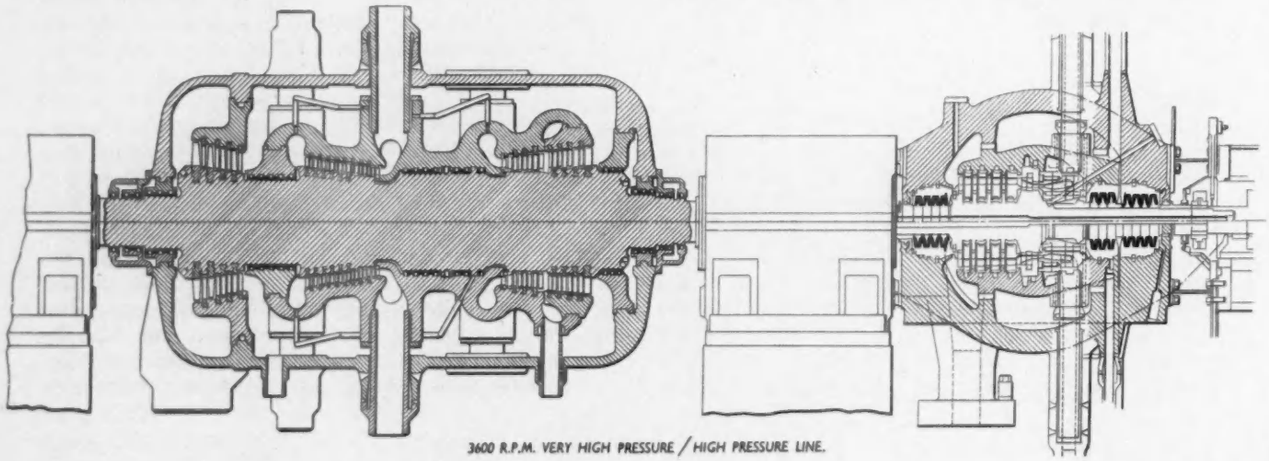
The 44in and 46in blades are new developments not yet in use.† Corresponding

* Merz and McLellan, London, England.

† 50in and 28in blades at 1800 and 3600 r.p.m. respectively have since been projected by Westinghouse.
Particulars in the order of the above table are as follows:

50	100	165·2	1572	2·0
28	56	103·7	1761	2·0

A 29in blade at 3600 r.p.m. is in development by GE.



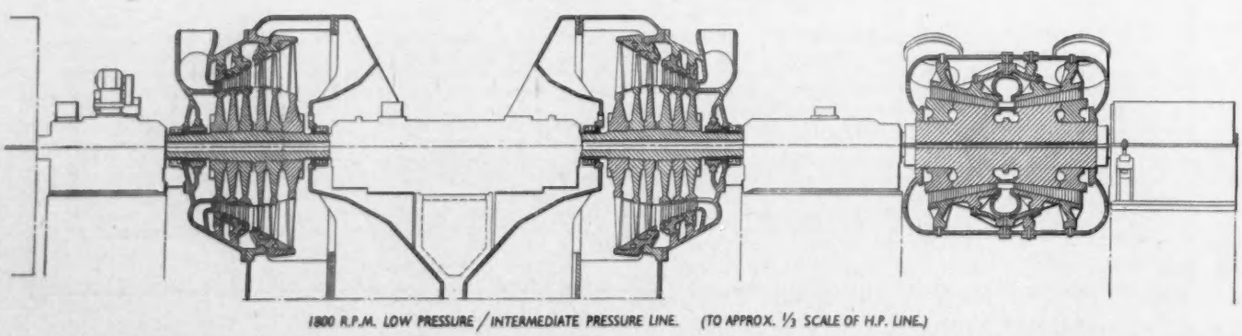


Fig. 2—325MW cross-compound, 3600/1800 r.p.m. turbine, 5000 lb per square inch, 1200 deg./1050 deg./1050 deg. Fah., for Eddystone 1

TABLE IX.—*Turbine Exhaust Limits*

Maker	Blade length, in	Rotor dia., in	Annulus area, square foot	Tip speed, foot per second	Ratio tip dia. to root dia.
1800 r.p.m.					
GE	43	89	124·3	1370	1·97
WE	44	88	126·7	1385	2·00
AC	46	86	132·8	1400	2·07
CAP ...	37·5	75	92	1180	2·00
3600 r.p.m.					
GE	26	46	41·1	1550	2·13
WE	25	50	40·9	1570	2·00
AC	26	45	40·5	1530	2·15

developments in England at 3000 r.p.m. are a 27in blade by several makers running with a tip speed of about 1400ft per second (some in use) and in development 30in and even a 36in blade running at a tip speed of 1780ft per second. The velocity of sound in steam at 90 deg. Fah. is about 1420ft per second, hence many of these blades are running supersonic. High ratio of tip to root diameter calls for considerable twist, from pure impulse at the root to high reaction at the tip, if the annulus is to be fully utilised. High velocity also calls for taper and means of reducing erosion by water droplets. The first blades of modern proportions came into use about 1937, but the need for twist had been explained as early as 1929 by Darrieus and had been tried throughout a turbine as early as 1926. The highest stressed part of the turbine and that calling for most development is the last row blade and its fastening. Once a design has been proven, it ordinarily remains current for many years. An alternative to long blades on few exhausts is more exhausts with shorter easier rated blades, for example, the four exhausts at 1800 r.p.m. on the 300MW Lake View machines. Designers differ as to the merit of the alternatives and also on details such as methods of blade support against vibration. It is a curious thing that practice has so far outrun testing that there is no uniform opinion as to what is the efficiency of a long twisted blade in wet steam with supersonic velocity at its tip, nor what benefit is obtainable by draining off the water. Millions of pounds worth of investment turns on this issue, and yet there is hardly any factual data anywhere in the world. All turbine designers still use something like the rule of 1 per cent reduction in efficiency per 1 per cent water, proposed by Baumann in 1906 when blade velocities, forms and tip to root ratios and drainage devices were very different. Increased use of reheat and double reheat has rather reduced the importance of the wetness issue, though the economics of a second reheat must turn very much on whether water could be removed mechanically. Nevertheless, it is an error to suppose that reheat is adopted primarily to produce a drier exhaust. The main justification has always been the thermodynamic gain.

As an alternative to the use of excessively long blades the Baumann exhaust should be mentioned (Fig. 5). This, which is in effect a duplex exhaust, was invented about 1915. It has been used in the past by several firms, but is now confined to Metropolitan-Vickers and one Russian builder. The exhaust area is increased by about 30 to 50 per cent above that of the last row annulus at the expense of some increase in axial length and some complication of the penultimate row of blades, which are often of the same length as the last row.

The reason for devoting so much space to the exhaust issue instead of the more dramatic hot part of the turbine, is that exhaust arrangement is to some degree a customer choice, whereas most other features are fixed by the maker. Moreover a large part of the turbine remains the same irrespective of cycle conditions. Most of the power is developed by the lower pressure part, and only the higher pressure cylinders are affected if high pressure and initial temperature are adopted. Reheat, however, which is now almost universal for first rank plant, introduces high temperature well down the turbine and, despite the low blade height, the designer may be driven to high stresses in relation to what the material can withstand at operating temperature. Consequently, putting up the reheat temperature to 1000 deg or 1050 deg. Fah. a few years ago meant that some blades fixing would not stand the rather high root stresses encountered by fairly long blades after the reheat point in 150MW sets and crumbling or cracking resulted.

The turbine designer accepts responsibility for the soundness of the forgings he uses, and throughout the history of steam turbines the forgemaster has at various stages been pressed to supply ingots somewhat beyond his current capability. Despite advances in non-destructive testing, unsound forgings occasionally go into service and a serious smash results.

There are, of course, many other things to be considered, such as expansion of casings and shafts, distortion of casings, bolting of the high-pressure flange, governing, alignment, balance, damping and vibrations, shaft whirl, gland arrangements, bearings and couplings. Any of these can be a designer's headache and all builders rely largely on past experience. Often compromise is necessary, i.e. design is an art, though there is room for considerable science. Each new advance or reversion to old ideas is liable to expose weaknesses hitherto undisclosed which have to be overcome by new methods to be devised by fresh development work. The results of misjudgment may be disastrous.

A new development

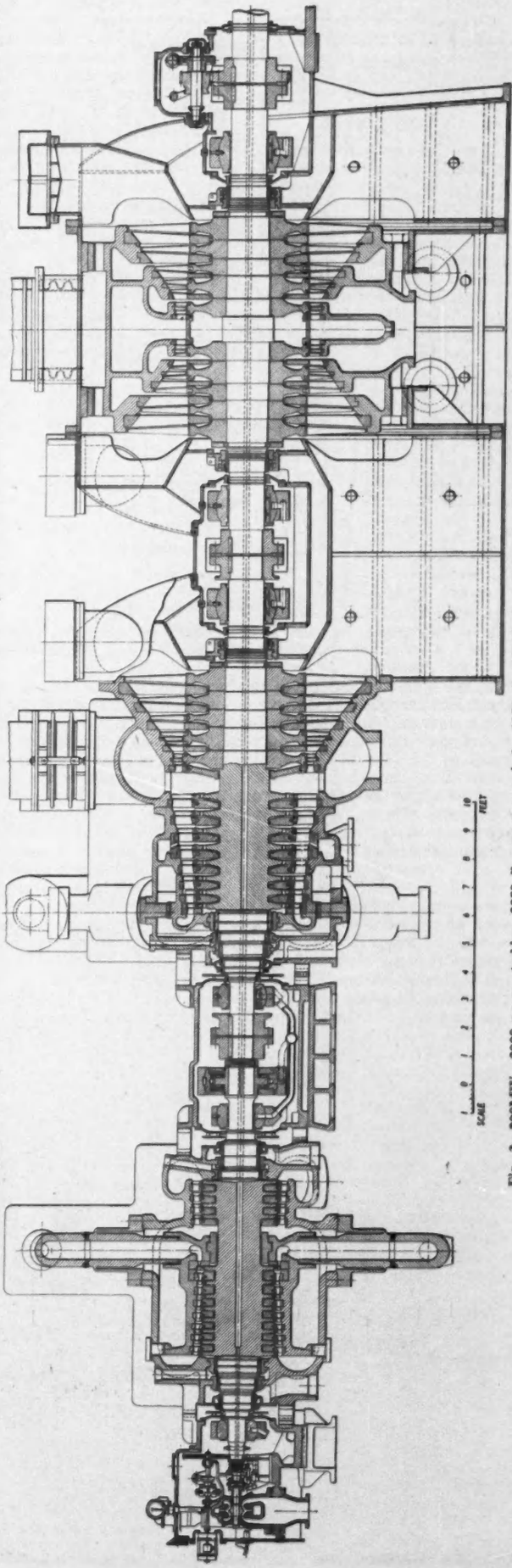


Fig. 3—200MW, 3000 r.p.m. turbine, 2350 lb per square inch, 1050 deg./1000 deg. Fah., for High Marnham

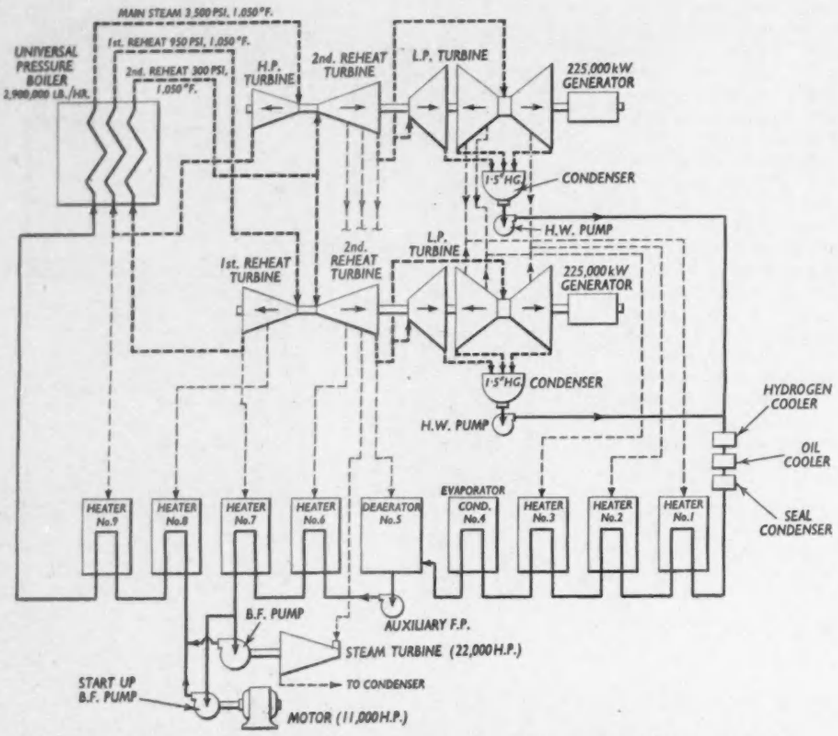


Fig. 4—Cycle diagram for Breed. 450MW, 3500 lb per square inch, 1050 deg./1050 deg./1050 deg. Fah., showing two 3600 r.p.m. lines, each with three exhausts

which has been adopted by a number of makers simultaneously is the construction of the low-pressure casing as a self-sufficient stiffened box structure capable of providing support to the internal inlay casing independent of any horizontal foundation steelwork beams, the use of which had become incongruous. There is also a very marked world trend to the use of solid couplings throughout machines.

Boilers

Now coming back to boilers, if we leave out oil and gas firing there are really only two ways of firing for large sizes, namely pulverised fuel and cyclones. The efficiency is not noticeably different. The advantage of cyclone firing lies partly in avoiding grinding, as (at least in the U.S.A.) the fuel is merely crushed to the size of rice, and, secondly, in the refuse not in the main going through the boiler. The excess air can also be reduced. Slag is more readily disposable than dust. On the other hand, the sensible heat loss in the molten ash can be significant, especially if ash content is high. The same object—that is, the extraction of much of the ash (where of suitable nature) in liquid form can be achieved by slag tap or so-called wet bottom furnaces with pulverised fuel. The ash abstraction in liquid form may vary with type of furnace from 45 per cent to as high as 90 per cent with cyclones. However, not all coals are suitable for slagging either in cyclones or normal furnaces. Also even with cyclones sufficient matter still goes through the boiler to call for precipitators on large plant to maintain standards necessary in Britain.

The remarkable thing about boiler design generally is the way it is always changing. In the past the great increase in height has been brought about by need for more reliable circulation as pressures have increased. Assisted circulation by pumps and forced flow in once-through boilers does not, however, reverse the trend, as height tends to provide the required increasingly long gas path without complication. A second stimulus to development in an empirical process is the need to avoid the snags of the last design. A common snag has been loss of availability through fouling of some sort. At one time a high rating in a small space was thought to be the goal. The result was that p.f. combustion chambers were too small and slagged up. When this was overcome by larger combustion chambers, new troubles then showed up such as sublimation and sintering, causing the superheater or economiser again to block (sometimes the air heater). These experiences were partly the consequence of scale factor.

The large cyclone-fired boilers in the U.S.A. went through a rather bad time a few years ago when, contrary to expectations, they proved very liable on Central Illinois coal, which has a high chlorine content, to blockage with soluble deposits in the second pass. Moreover, no established method, neither sootblowing, water lancing, nor shot rain, would move the deposits from the tubes, except into worse places. The "tower" or single-pass, 450MW, double-sided, eight-cyclone design for Breed (Fig. 6) and the equivalent p.f. design for Philip Sporn, with burners in both sides and ends, embody the result of this experience. Both these boilers are incidentally once-through installations for supercritical pressure of 3625 lb per square inch. The gases encounter reduced tube spacing as they go up, and it is hoped that when deposits are dislodged they will fall into wider spaces and so drop right through. "Tower" boilers have been built before in Sweden and Germany and are claimed to result in lower costs.

Many modern boilers now have recirculation of gases either as a means of control of reheat temperature or merely to reduce the initial temperature in the combustion chamber. This device was used at North Tees and Barking in the early days in order to overcome the effects of high feed temperature. Recirculation of gases has other effects on combustion which were not foreseen and can

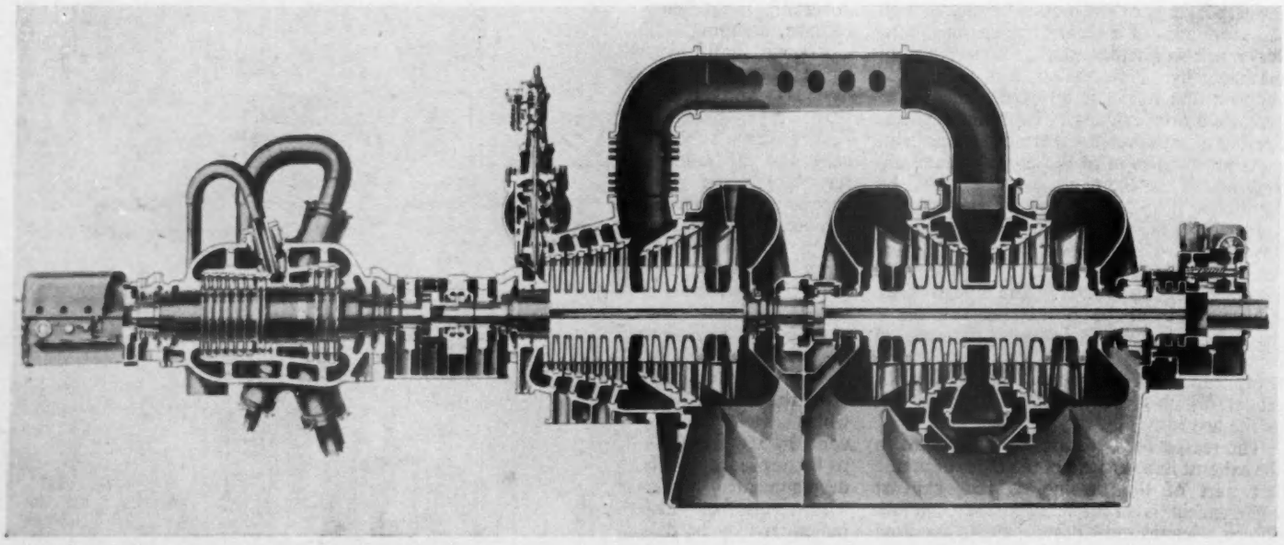


Fig. 5—200MW, 3000 r.p.m. turbine, 2350 lb per square inch, 1050 deg./1000 deg. Fah., for Willington "B" (Illustrating Baumann exhausts)

conceivably prevent fouling troubles. Other methods of control of reheat are twin combustion chambers, tilting burners and the older device of dampers to control flows of gases.

Fig. 8 shows an artist's impression of the largest boiler so far ordered in the world‡; it is for the 550MW unit at Thorpe Marsh, England. It has two combustion chambers, each divided by a water wall and corner firing with eight mills.

It should be mentioned that as welded sheet steel casings are pressure-tight many boilers now have pressurised firing, i.e. they run without i.d. fan. This greatly reduces inward leakage of air and hence the stack loss. One development in boiler design which is confidently predicted is to take pressurising a stage further by putting a compressor before the combustion chamber and a gas turbine after. This amounts to a Velox boiler which was invented in Europe about 1931, but has so far been confined to oil or gaseous fuel. If (as may be expected) this cannot work on coal, there is still the halfway house of putting the gas turbine before the combustion chamber and discharging the hot exhaust gases into the boiler. This again entails running the gas turbine on oil or gas. The gas turbine can then produce something like 15 per cent additional power and can show gains of 4 per cent on good cycles and more on bad cycles. This was investigated in 1938 for Dunston power station in England where there was at the time waste coke oven gas, but was not adopted, as then showing insufficient return. The potential gain is now larger by virtue of the higher turbine temperatures permissible. The basic reason for the gain is of interest. It is because the gas turbine power is generated in effect by a superposition cycle on the combustion air and therefore ideally without rejection of heat. Thus the benefit is accounted for in precisely the same way as most of that obtained by feed heating or raising of pressure and temperature, i.e. getting out more work before throwing away the inevitable tail-end heat. The scheme is not without its practical drawbacks and may take some time to become accepted, but it is one way out of a potential impasse in improvement of cycles. However, it has probably appeared to each generation that cycles were about to reach the end of development.

Boiler construction has undergone a great change in the last twenty years largely because of acceptance of welding. Not only have combustion chambers become gradually taller; tube expansion is going or gone and smaller tubes tend to be used. Prefabrication is becoming usual. Drums disappear for pressures above 3000 lb order. This is just as well, since a single drum 107ft long by 7ft diameter for a boiler of 325MW weighs 260 tons and creates too serious a transport problem. In any case the use of a drum as a means of joining together a lot of tubes has already been abandoned. The convection part of the boiler, once the major part, has disappeared. Nearly all the evaporation is done by radiant heat in the furnace wall tubes. The fraction of the heat in the fuel picked up by the superheater and reheater is continually growing. Radiant superheaters and reheaters commonly occupy part of the walls. In the U.S.A. the rotary (Ljungstrom) air heater has largely collared the field in the larger sizes and these become enormous, e.g. two of 28ft diameter, each weighing 260 tons at River Rouge No. 3 unit of 300MW. If the gas turbine scheme comes into use, these air heaters will in turn disappear and there will be a return to low temperature economisers with possibly a greater freedom to adopt low stack temperatures.

‡ In steam rating the Widows Creek boiler of 3 850,000 lb per hour is the largest, which draws attention to the high "capability" rating evidently expected from the turbine.

In the United Kingdom standards were fixed in 1931 with which any new plant had to comply before receiving official consent. *inter alia* these required that the chimney height should be at least two and a half times the building height, to ensure that the gases would not be brought down by eddies in lee of the building. This rule has been found to be very accurate. It entailed in general the use of tall free standing brick or concrete chimneys, such as are now becoming general in the U.S.A.

A second requirement was that the best available methods should be adopted for eliminating dust, and this was taken to mean electrostatic precipitators. In some cases these are now combined with mechanical arresters and combined efficiencies over 99 per cent are claimed. Gas washing for elimination of sulphur oxides was imposed on three stations in London, England, but is too costly for general application.

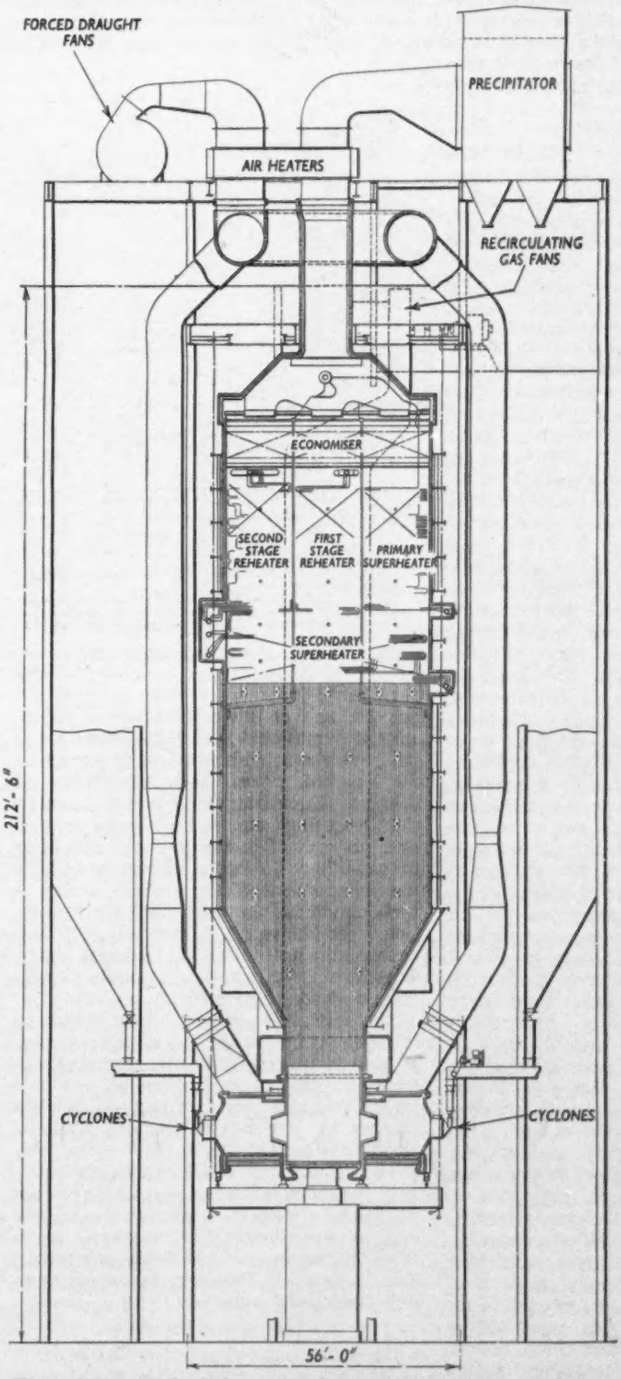


Fig. 6—Cyclone fired, single-pass boiler, 2,900.000 lb per hour, for Breed. Once-through, supercritical, double reheat, 3625 lb per square inch, 1050 deg./1050 deg./1050 deg. Fah.

Alternators

The size of turbo-alternators at a given speed has traditionally been limited by the rating of the alternator. In about 1924 the limit rose to 25MW at 3000 r.p.m. It gradually climbed with the same techniques of air cooling to 50MW and even to 60MW as early as 1931 in Europe. The introduction of hydrogen cooling changed the picture, 60MW became easy, and without great alterations ratings up to 100MW became possible at 3000 r.p.m. or about 75MW at 3600 r.p.m. in the U.S.A. A further recent development, "inner" cooling has now come into use which so greatly relieves congestion in the rotor as to render the stator for the present the limiting feature. Consequently new methods are now in turn being adopted for more intensive stator cooling. In the one type the armature bars are cooled by forced circulation of high-pressure hydrogen through the hollow copper conductors. In another a liquid, either purified water or oil, is similarly circulated. This has raised the limit rating (imposed by transportability) to possibly 300MW at European frequency and 350 at 60 c/s. The largest alternator in use in Europe is of 150MW (several, all with orthodox stators), but 300 is thought to be possible at 3000 r.p.m. The largest set in service at 3600 r.p.m. is 250MW at Gallatin, but a 325MW machine is on order for Helena station of Middle South Utilities. Some degree of scope for variation of kilowatt rating of a given machine is offered by varying the rated power factor, the short circuit ratio (s.c.r.) and the hydrogen pressure. Increase of rating on a given frame size inherently tends to lower the s.c.r. and figures as low as 0·45 have been adopted: 0·64 is regarded as standard.

The rotor forgings of these sets are not much larger than what would have been employed for sets of 60MW to 70MW with air cooling. The reduction of weight per

kilovolt-ampere of stator without liquid cooling is not so startling. The hydrogen pressure is now commonly 40 lb per square inch. Efficiencies are not greatly affected, but may be slightly worse. Water-cooled stators are in use in England at Bold and Tilbury and there is one oil-cooled stator at Eastlake in U.S.A. Research is now being done in the U.S.A. on water.

The new designs have brought with them considerable complication and refinement of the copper conductors in the rotor which are now no longer the rather crudely bent strip on edge at one time traditional. Since temperatures are now more closely controlled and sometimes also the copper is alloyed with silver, rotor copper distortion which put a large amount of plant out of action a few years ago is now not expected to occur. The exciter assumes very large proportions compared with the alternator and its drive and that of the hydrogen circulating fan (if used) become a major factor in design, each firm having its own solution not necessarily yet crystallised.

Boiler-Feed Pumps and Their Drive

Higher pressures bring in a new factor, that is, the very great increase of boiler-feed pump power. This was about 1 per cent at 600 lb per square inch and would increase roughly linearly with pressure, except that the steam rate also falls somewhat with higher temperature and multiple reheat. At 4500 lb per square inch the feed pump consumes about 4½ per cent of turbine output, so a 300MW set requires 14,000kW or a 450MW set 22,000kW. This change brings about several new conditions. First the feed pump power can no longer be neglected in discussing the cycle; it has thus become accepted practice (as was always the case in Britain) to include the temperature rise put in by the boiler feed work in the water and to credit the turbine with it. Thus gross turbine heat rates in the U.S.A. have apparently improved. The corresponding work is, of course, deducted in getting out the station heat rate, but not ordinarily in the turbine heat rate (though there is no reason why this should not be done to give a realistic net turbine heat rate including boiler feed pump).

Secondly, the horsepower required to drive a 100 per cent rated pump has gone up to the order of 8000 h.p. to 22,000 h.p. depending on the size of unit and can go still higher. This has caused some designers to think that motor drive is inapplicable and to put the boiler-feed pump on the tail of the main turbine shaft, as at Astoria, or to drive it by a separate steam turbine as at Breed. A gas turbine has also been suggested.

The very large power means that methods of reducing it at part load become important. The only satisfactory method is variable speed, which is beneficial also in reducing wear on the control valves. Secondly, a higher speed than 3000 or 3600 becomes desirable. When step-up gears are used it is advantageous to use a four-pole motor. Squirrel cage motors with hydraulic couplings or slipring motors are, however, still in the picture. There are various possibilities, e.g. for smaller units half the pump can be driven at constant speed and the other half at variable speed both from the same motor, so keeping within limits of hydraulic couplings (as at Philo). Alternatively a steam turbine can do the job more elegantly and without slip losses. This has caused a reversal of the former swing away from steam-driven auxiliaries. The boiler-feed steam turbine is now of a sufficient size to design for high efficiency at, say, 7000 r.p.m. It can utilise steam at lower pressure, e.g. from the cold reheat line, and discharge to its own condenser. In this case, unless provided with an alternative live steam supply, it cannot run until the main unit is on load and at least a small size standby motor-driven pump has to be used at no load and light load, as is the case when the pump is driven from the main turbine shaft. The economics of alternatives is still a subject for debate and has not yet been fully settled.

Boiler-feed pump power can also be conserved in a " unitised " plant by dropping the boiler pressure at light load, as was done in Germany before 1939. However, this is not desirable with supercritical pressure, where the saving would be largest.

Other Auxiliaries

With the avoidance of the i.d. fan and adoption of a better cycle other auxiliary power tends to diminish in proportion. A larger f.d. fan can do the same job as f.d. and i.d. and at less expenditure of power, since it pumps cold fluid. Also there is less infiltration which hitherto partly accounted for high i.d. power when using balanced draught. Circulating water pumps, formerly the largest single auxiliaries, taking 1 per cent or 2 per cent of power generated according to conditions (i.e. open circuit or cooling towers) now tend to take a lesser fraction as cycle conditions improve, since the heat rejected per kilowatt falls markedly, e.g. it is equal to the heat utilised in the latest plants, whereas twenty-five years ago double the heat utilised had to be rejected.

The only other auxiliary to be mentioned is the air pump. In the U.S.A. reciprocating air pumps are in wide use often together with steam jet air pumps supplied off the cold reheat line and therefore not usable when starting up. On the Continent the water jet ejector has been in regular use for some forty years. It is more efficient and less costly than the steam jet ejector, but its use has not penetrated elsewhere. However, this may be expected since the supply of steam jet ejectors from high-pressure and high-temperature steam ranges is becoming inconvenient as well as absurdly wasteful.

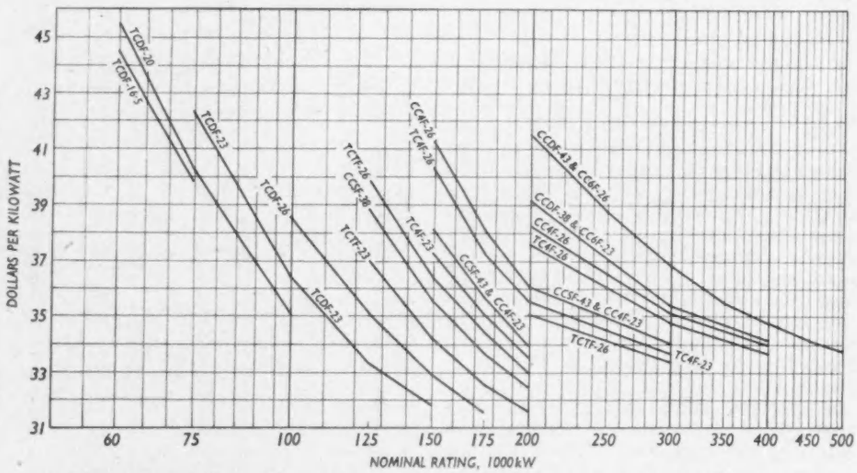
Outdoor Stations

One of the aims of power station design is to attain a given performance at minimum cost. Very substantial savings in cost per kilowatt are made by adopting large units. With orthodox designs little else can be done except to buy plant at the right time. However, one apparent way to cheapen power stations is to omit the buildings. The outdoor idea first caught on in the southern parts of the U.S.A. where summer temperatures are high and winters not too cold. It is especially attractive in gas or oil-fired stations where no bunkers are required. The concept has spread to more northerly latitudes, as far as New York and even to coal-fired stations. The savings that can be made are not as profound as might be supposed. They have been put at about 6 dollars to 10 dollars per kilowatt for an outdoor boiler-house. The value of the radiation loss from the boilers, which is ordinarily recovered by sucking hot air from the top of the boiler-house, has to be offset against this saving. This is worth about 1 per cent, or, say, 2 dollars per kilowatt, though it must be conceded that combustion air can also be heated by low value bled steam. When proper allowance is made also for extra cost of maintenance, frost precautions, &c., some people would say there is no saving or, indeed, it costs money to go outdoors. In England there are semi-outdoor boilers at Ince and outdoor boilers at Little Barford " B."

A halfway scheme, in which the boiler-house takes the form of a lightweight sheet covering supported from the boiler structure, is a more satisfactory compromise for use in climates where either much rain or cold weather has to be allowed for. The putting of the turbine in the open can also save money, but few people would accept this as reasonable for cold climates, even with " walk-in " enclosure of vital parts, such as the governor end and complete enclosure below decks as is usual. The combined saving on boiler-house and turbine-house has been put at the order of 12 dollars to 30 dollars per kilowatt, but in this is often concealed other savings made by general all round economies. These are really extraneous in that they could be made anywhere, but they are difficult to separate in the total expenditure.

Water Preparation

Adoption of high-steam conditions has always been dependent on adequate water chemistry. Supercritical pressure can only



(1) Letters on curves indicate turbine type and number of flows. Numbers on curves are length of last stage in inches.
(2) Steam conditions :
50,000kW to 100,000kW—1450 lb per square inch gauge, 1000/1000 deg. Fah.
100,000kW to 200,000kW—1800 lb per square inch gauge, 1000/1000 deg. Fah.
200,000kW to 500,000kW—2400 lb per square inch gauge, 1000/1000 deg. Fah.

Fig. 7—Pattern of published turbine-generator prices for size and type variation. July, 1957, price level. (General Electric Company, U.S.A.)*

* From *Steam Turbine Performance and Economics*, by Bartlett, McGraw-Hill, 1958, page 285.

be adopted if feed water is practically pure. A few years ago present maximum pressures were not practicable because of reliance on distillation followed by correction of pH by dissolved salts. Distillation is now not regarded as good enough. Demineralisation can produce purer water than commercial evaporators. Solid substances can no longer be employed for pH correction, for conditioning or for oxygen scavenging. Their role is accordingly taken over by the gases, ammonia and hydrazine. However, this is no revolution; practice has gradually been working that way for some time at lower pressures, and the new supercritical cycles can utilise experience already gained particularly in Germany at 1500 lb per square inch. New techniques are also being devised to preserve high purity of the water, e.g. welding in of condenser tubes or sealing the expanded joints in the tube plate with " Neoprene " together with compartmental division of the condenser to separate

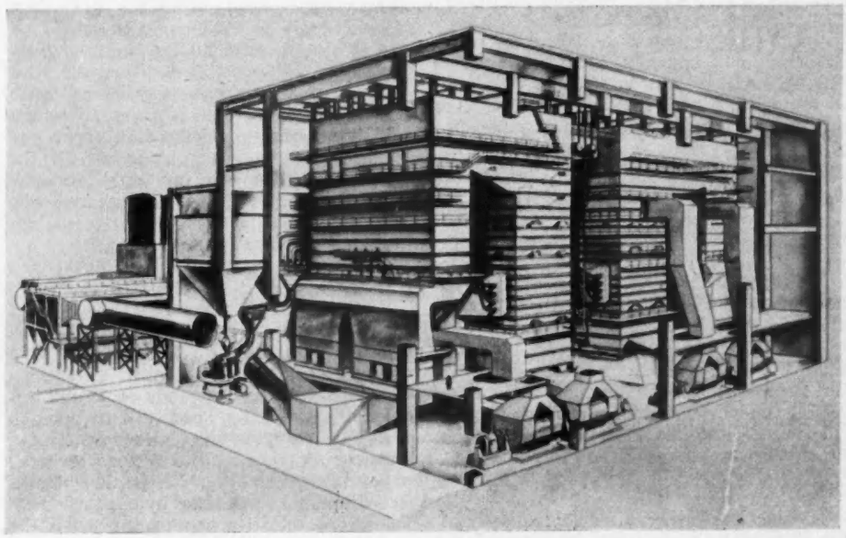


Fig. 8—550MW reheat boiler for Thorpe Marsh, 3,750,000 lb per hour, 2400 lb per square inch, 1055 deg./1055 deg. Fah., duplicate twin combustion chambers

off contaminated condensate for individual demineralising, so that even a sudden leak assumed to be near a tube plate will not result in salts entering the boiler, since the contaminated water supply is shut off automatically and a store of pure water called on. One incidental advantage will be that feed heaters will have cleaner surfaces than ever before and so show a better performance.

Cooling Water

The rational use of river water for cooling is a subject which receives little mention. However, it is of growing importance. Even large rivers such as the Ohio, in the U.S.A., are already becoming warm (some in the U.K. already too warm), but in the U.K. we have sea-water all around us and we must adapt our thoughts to make its use feasible.

An interesting problem is how to design river intakes in such a way as to swallow a large fraction of a stream. It can be affirmed that this is rarely done—a large amount of cold water commonly slips past; this means that when abstraction is anywhere near the full river flow, other water must recirculate from the outlet back to the inlet in reverse flow on the surface. Thus the river is not properly utilised. Some people will find this difficult to believe, but there is no doubt that it occurs, unless there is a weir interposed. Thus the distance of separation between intake and outlet assumes some importance. This " pond " may lose very little heat to the atmosphere, but will nevertheless show considerable drop in surface temperature brought about by interchange between the two oppositely flowing currents which are separated by their densities. The resulting heat transfer between them calculated from observed figures is many times the loss to the atmosphere.

In England, where there are few large rivers, generation has come to depend very largely on large natural draught concrete cooling towers—these will be used for even 1000MW and 1200MW stations. Ratings are as high as 5,400,000 Imperial gallons per hour, base diameter 266ft and height 350ft. They can produce as cool water over the year as an overloaded estuary and allow inland sites near the collieries and with good foundation conditions to be exploited. Economically they are a much better proposition than the mechanical draught towers fashionable in the U.S.A. They are little more expensive in first cost, but have a longer life, involve no fan power and less maintenance, completely prevent recirculation of air and are more reliable. In this respect Great Britain is far ahead of the U.S.A. Germany is retrogressing.

A further European development is the air-cooled condenser of which there are two types. One, of German origin, condenses steam direct and uses no circulating water. Sizes up to 32MW are built. The second employs a dry extended surface cooler in conjunction with a jet condenser working on recirculated recooled pure water. A 120MW unit is being built in England as a research project, since it appears commercially uneconomic at normal prices of make-up water.

Gas Turbines

Gas turbines are not new. They had a long and chequered history before Whittle. The first undoubtedly successful one, in that it fulfilled its guarantees, was the historic 4000kW machine for Neuchatel run in 1939 and exhibited at the Swiss National exhibition. Mention of the gas turbine has been made so far only as an adjunct to a steam cycle, but it can, of course, given suitable fuel, stand on its own feet. Canada will soon be the country with the largest capacity of gas turbine plant installed. Favourable conditions are the demand for high output in cold weather, not too large a unit size (say 30MW) and either a cheap clean fuel, such as natural gas, or a not very high utilisation factor. This means that a very high efficiency is not called for, but a low capital cost compromise is acceptable.

In England the high hopes at one time placed on the gas turbine because of its success in the air are still far from realised. It has not achieved much of value either in generating stations or locomotives, and coal-firing is still in the distant future in spite of the work of Mordell at McGill University. Disillusion is not confined to England, as similar disappointments have been experienced in other countries. To some of us this was no surprise. It is a common failing to attribute to the unknown competitor all the hopeful virtues and to the established one all its known practical drawbacks. There is a curious irrational glamour about the gas turbine and its forerunner the gas engine which has its roots in some mistaken claims by early thermodynamic experts. In this connection it is worth recalling that Sir Frederick Bramwell prophesied in 1881 that " within fifty years steam machinery would be found only in museums " and bequeathed a sum of money to endow a lecture to be delivered fifty years later reviewing power generation. Sir Alfred Ewing in giving the lecture in 1931 had to report that it was the gas engine that was practically dead and steam in most fields still very much alive. Since then the internal combustion engine has cut severely into regions once occupied by steam, e.g. in transport of all kinds. Steam is, however, ordinarily still the most economical choice for large thermal power generation and that position is not likely to be altered even by present developments in atomic power. Engineers need have no shame in still using what they may be taught is an inherently unsuitable fluid. It is paradoxical that water, owing to its thermodynamic shortcomings, is the most economical to use of all the fluids we know.

Novelties and their Origins

It is worth pointing out that few features mentioned as used in modern top-class stations are really new. Multiple reheat was patented by Ferranti in 1905. Reheat and multiple-stage feed heating were used in 1916 at Blaydon Burn. Reheat was used in 1918 at North Tees and served as a model for the original Philo No. 1 in the U.S.A. (1924). The Barking " A " symmetrical two-shaft set with two high-speed lines and four exhausts has been mentioned (1922). The Benson supercritical boiler was invented by Mark Benson, a Czech living in England, and the rights were sold by English Electric to Siemens Schuckert in Germany, who did the major development work, leading to some 300 subcritical Benson units in Europe and also the first supercritical plant at Huels (1956). Direct cooling of rotor copper was patented in Europe in 1909 and was in use in 1934. Several water-cooled rotors were in service at Carville " B " in 1916 and at Dunston " A. " Oil cooling of alternator stator windings was tried by Parsons as early as 1889 and water cooling by 1904. It was again in use in 1957 at Bold. Three gas turbines were built by C. H. Merz as a private venture between 1901 and 1909, though none of them turned themselves round. The combination of gas turbine and unpressurised boiler was the subject of a report on Dunston " A " in 1938, but was not regarded as an invention, since the " Velox " boiler already existed in 1931.

ADDENDUM

The information given in the first part of this article should be brought up to date by drawing attention to some of the more notable orders that have been placed recently. These orders include a 600MW cross compound set at 3600/1800 r.p.m., 2400 lb per square inch, 1050/1000 deg. Fah., with four exhausts from G.E. of U.S.A. for Paradise Station of T.V.A.; boiler by Combustion Engineering. A 500MW set from G.E. for Will County No. 4 (presumably cross-compound 3600/1800 r.p.m.). A 550MW set at 3000/1500 r.p.m., 2300 lb per square inch, 1050/1050 deg. Fah. with four exhausts from A.E.I. for Thorpe Marsh No. 2; a 3,750,000 lb per hour boiler from Babcock and Wilcox. Two 350MW sets at 3000 r.p.m. single-line, 2300 lb per square inch, 1050/1050 deg. Fah. with four exhausts from The English Electric Company for Drakelow "C"; two 2,450,000 lb per hour boilers from John Thompson. Two 300MW sets at 3000 r.p.m., single-line, 2300 lb per square inch, 1050/1050 deg. Fah. with four exhausts from A.E.I. for West Thurrock; two 2,000,000 lb per hour boilers from Babcock and Wilcox. Two 300MW sets from A.E.I. for Lake View Station, Canada. Two 200MW sets at 3000 r.p.m., 1500 lb per square inch, 1050 deg. Fah. with three exhausts from A.E.I. for Hazelwood Station, Australia; two 1,650,000 lb per hour boilers from Babcock and Wilcox.

It is also noted that the Brown Boveri 500MW set ordered by T.V.A., is not to go to Colbert (as stated in the footnote on page 250 *ante*), but to an unnamed station.

Employer's Liability for Other People's Premises

By a BARRISTER-AT-LAW

IT is one of the great tragedies of all times that, whilst it is freely recognised that absolute power will cause greater damage than dry rot in the stable roof, yet no one has yet devised a satisfactory remedy for the inevitable frustrations of divided responsibility. It might be thought that if it were the duty of two people to see that a particular piece of work was carried out, the execution of the job was a double certainty; human nature, however, inevitably accepts the excuse that each thought the other was going to undertake the responsibility, instead of visiting the penalty of sloth upon both heads with equal severity.

Strangely enough, the law has been almost as blameworthy in its approach to this problem as human nature, and it is only in very recent times that many of the problems of divided blame have been met by the rather obvious solution of divided liability. An illustration of the modern approach of the courts may be obtained from the case of a fitter who fell from the top of some stairs whilst on his way to the machine house of a lift.* The original judgment of the High Court, after being reversed in the Court of Appeal, has now been restored in the House of Lords, and the award in favour of the injured man against both his employers and the owners of the premises on which he was working has been upheld. Although one member of the House of Lords "deprecated the tendency to treat the relation of employer and skilled workman as equivalent to that of a nurse and imbecile child," the man himself was held not to have willingly accepted the risk of his work. In spite of the fact, therefore, that it was his own action of deliberately pulling on a broken door which started all the trouble, he receives the whole value of his damages, undiminished on account of any carelessness of his own.

The fitter was an employee of a company whose business was the maintenance and repair of lifts, and on the day of the accident he was sent on to the premises of a customer to overhaul the lift there. He was familiar with the premises, as he had been there a number of times before, and had, in fact, complained four times of the condition of a door through which he had to pass to obtain access to the machine house on the roof of the premises. The substance of his complaint was that the hinge of the left-hand door was in a bad condition, but this apparently was not considered of much moment by those responsible, for nothing had been done. On the day in question the fitter noticed that the left-hand door was held in position with a wire, but he apparently paid no more attention than usual on this account. The doors were at the top of a ladder 11ft high, and were secured by a bolt on the outside of the right-hand door, and two bolts on the inside of the left-hand door. The fitter unbolted the right-hand door and, after testing the left-hand door, pulled upon it to lift himself into the machine house. The door gave way, and he fell and was injured.

* Smith *v.* Austin Lifts. 1959, 1, W.L.R. 100.

HIGH COURT AWARD

He sued the owners of the premises and his employers for damages for his injuries, and before the High Court judge was successful in obtaining judgment against both—his award being apportioned, as the blame was apportioned, 20 per cent to the employer and 80 per cent to the owners of the premises. The Court of Appeal held neither liable, but on appeal to the House of Lords the Court of Appeal were overruled and the original judgment of the High Court judge was restored.

The basis of the claim was that the employers and the occupiers of the premises had been negligent in the performance of their duties towards him. As it is up to the plaintiff in an action to specify both the duty and the breach of it, the trial of the action resolved itself into two or three fairly simple questions. It was the duty of the employer, it was said on behalf of the man, to ensure that the premises in which he was required to work should be safe, and it was the duty of the occupiers of the premises to ensure, for him as well as for all other persons who came into their premises on business, or at their invitation, that they took reasonable care to see that the premises, and the means of access were reasonably safe. (The law on this point has, since the date of the accident, been changed by the passing of the Occupiers' Liability Act, but the duty remains substantially the same.)

On behalf of the employers and the occupiers of the premises it was suggested that as the fitter had already complained on a number of occasions about the condition of the doors, he must be taken to be aware of their condition, and thus himself be at least in large part to blame for the accident: it is folly to pull with the whole weight, some 11ft above floor level, upon a door which is known to be broken. This was the argument which succeeded in the Court of Appeal.

The House of Lords, however, with varying degrees of conviction among the different members, restored the judgment of the High Court judge in favour of the workman. As always, their judgments point to some fine distinctions in the law. They analyse the state of mind of a workman who takes a calculated risk in his work and the liabilities and different degrees of duty imposed upon employers who send workmen out to the premises of others, and those who receive workmen on their premises. It seems at first sight that if the workmen knew the door to be defective, then that is an end to the matter. This, however, is to ignore the obligations of a man who is under the orders of his employer, and under an obligation to do his work, in spite of obstacles, as quickly and efficiently as reasonably possible. A man sees a defective door and very rightly reports the matter; this particular defective door the workman had reported no fewer than four times. What is he to do on the fifth time, when he sees the door apparently in the same state, barring his entrance to his work? The obvious answer is that he must do his best to comply with his employer's instructions for the maintenance of the lift without running any undue risks.

THE WORKING MAN'S RISK

There is always some risk, however, in dealing with a door which is known to be defective at the top of a flight of stairs, and the problem reaches the courts only when some risk has been taken and some unfortunate consequences have ensued. The approach of the courts, therefore, is to examine the risk actually taken, and to decide whether it was taken voluntarily, or whether it was forced upon the workman by circumstances. Taking this line of approach, it begins to be understandable how, without "equating the relationship of employer and skilled workman to that of nurse and imbecile child" (to return to Viscount Simonds's expression), the decision could be given in the workman's favour, and in the proportion of 20 per cent against the employer and 80 per cent against the occupiers of the premises. The employer was invited on to the premises to repair or maintain a lift, and the employer, with knowledge of a defective door which he himself had reported to the occupiers four times, accepts the invitation and sends along a skilled workman. The workman arrives, sees a danger and commences to climb to his place of work. As far as the occupiers of the premises were concerned, the man could have walked off in disgust at seeing the door in the same broken state as on his last visit, but between the workman and the employer, the man was under a duty to do his best to get on with his job. The obligation upon the employer, then, to ensure the safety of the premises was the higher, because it was his orders which bound the man to attempt to pass the defective door.

BELIEVING IT SAFE

It was not, after all, the willing acceptance by the workman of an obvious risk, as Lord Denning observed. The man knew the door was defective, but he must obviously have said to himself: "I know it is a bit risky, but as long as I am careful I shall be all right." These may be famous last words, but they represent a sensible working

approach to a broken door before the accident occurs. The man did not, we surmise, say to himself that he would very likely fall however careful he was. "It seemed safe enough," he said afterwards of the door, and to say that he ought to have known better is only to admit that he did not. That is, at any rate, the decision of the House of Lords.

This being so, the employer who sends out men to work on the premises of others is obviously in a difficult position. He is under certain obligations to ensure the safety of his men which, for very good reasons, he is not always in a position to fulfil. The most obvious very good reason is that he is not in his own workshop. Just as the employer in the case just discussed did no more than pass on to the occupiers of the premises to which he sent his men their complaint that the door was defective, so it is not always easy for any employer to ensure that the premises to which his men are sent comply with the best standards for personal safety. In extreme cases he may, of course, refuse to undertake the work offered, but situations very seldom are taken to extremes, and employers are usually faced with just such a situation as confronted the House of Lords over the lift doors. The door is broken and there is very little in the job of having it mended, but nobody bothers, because it is a little out of the usual run of things. The foreman has many other jobs on hand, and the door is left until in one case in a thousand, an accident happens.

The only way to prevent such accidents is for the employer to take it upon himself to ensure that the door is repaired. If, on a second complaint, nothing is done, this is a fair indication that the occupiers are not taking the matter very seriously, and the employer should himself ensure by personal inquiry, or by sending round a foreman before the next maintenance visit, that his men are not asked to run unnecessary risks. After that, he can only ask permission to effect the repair himself, or refuse to send round a workman until the matter is put right.

Hidden Dangers

That much is clear when the danger is apparent. Many dangers are, however, not apparent at all. It is not many years ago that the case† came before the courts of a plumber who was killed in a loft in most unusual circumstances. A house had just been sold, and the new owner wished to have it put into good order before he moved in. A plumber went up into the loft to check the water installations there, and was electrocuted when he put his hand into the water storage tank. He was standing on some steel plates which had been put into the roof some years before, during the war, as a precaution against incendiary bombs. Unfortunately, care had not been taken at the time over where they were laid, and one of them had cut into an electric wire running over the rafters, with the result that the plumber unwittingly completed a circuit to earth.

His mother, as his dependant, sued his employers and the person who was buying the house, alleging that either or both were under a duty to take reasonable care to see that the premises were safe. The action failed, first, because the judge came to a decision on the law which, in the light of this later case, cannot now stand ; (he said the employer was under no duty to make the premises safe, or even to see that they were safe for his workman) ; second, and this was the factor which prevented the case from going to the Court of Appeal and thus making, possibly, fresh law, the judge felt that the danger was so unusual that even if the employer was under a duty to take all reasonable care for the safety of his men, it was stretching the imagination too far to suppose that the reasonable, prudent employer would think it necessary to inspect for electrical faults before he sent a plumber into the loft to look to the water tank.

In coming to his decision in this case, however, the judge was obliged to discount some authoritative statements of the law from a number of different judges, and this decision, with its rather extreme facts, did nothing at the time to resolve the uncertainty in the precise duties of the employer who sent his men on to the premises of others.

The Practical Aspect

Now that the uncertainty has been resolved, by the decision of the opening paragraphs above, at least to the extent that it is now clear that the employer has a fairly high responsibility, the employer is immediately faced with the obvious practical difficulty on how he is to fulfil that duty even as far as inspection of the premises. The duty is a personal one, cast by law upon the employer, but he may, of course, and if he is not an expert in such matters he ought, to send one of his supervisory staff instead of going personally. Naturally, in the case of a limited company, there is no employer to go personally, and the duty must be performed by one of the supervisory staff or a safety officer. In some cases, though, and one might say in the majority of cases, the person who is best in a position to judge the safety of the premises is the man who is going to do the job. Is it permissible for the employer to say to his workmen, if skilled and reasonably responsible, that they themselves should first inspect the premises for safety before undertaking the work ? To take once again the case of the lift maintenance engineer in the opening paragraphs. He knew the premises well, and had already reported on the broken door. He would normally be the best person to inspect the premises on behalf of his employer, because he knew what to look for, and was to a certain extent at any rate already acquainted with the danger which, for a foreman sent fresh to the spot, might constitute a novel danger. The answer to this is that a supervisor or foreman is in a rather different position from the man who is sent to do the job, for the supervisor has to report to the employer, and thus leave to him the decision on the safety of the premises. The man who is sent to do the job might be the best man to go first to inspect the premises if he was not only well acquainted with the law and practice of safety for workmen, but also had instructions and authority to return without touching the job in the event of his finding anything on the premises worthy of report which endangered his own safety. That is the short answer which prevents an obvious solution to the practical problem posed for the employer. His duty to take all reasonable steps for the safety of his employees on the premises of others is not discharged merely by his giving instructions to his skilled staff that they shall first inspect for safety before starting the job.

The employer's duty goes beyond this simple (but, it must be remembered, necessary) step. He must pursue with all due diligence, any inquiry or complaint which is brought to his notice and, in short, take all reasonable steps to ensure that his men, even skilled ones, are preserved from the necessity of taking risks in the performance of their employer's work. As far as unskilled men are concerned, the duty of the employer is higher, and it would not normally be sufficient either to rely upon the occupiers of premises to undertake responsibility for their safety, nor would it do to rely upon the unskilled man himself as an inspector of safety. Some supervisory senior member of the staff ought to be sent along, at least in the first place.

There is another reason why the employer should, in any event, refrain from sending unskilled labour on to the premises of others without supervision : irrespective of the condition of the premises the employer is under a duty to devise for all his employees a system of work which provides against all the known and reasonably foreseeable risks of the work which the man is sent to do. It is not enough for the employer to sit back and say that the man on the job is the best man to devise rules and a system of working for his own safety. The skilled workman knows the risks of his work, and provided the employer impresses upon him, where applicable, the necessity of observing any statutory requirements (such as the use of safety apparatus at a height, or compliance with the building safety regulations if he is working on engineering works in a new building), it is reasonable to expect that the skilled man will do the job carefully and properly, and without undue risk. Even so, he is at times tempted to take short cuts. If these involve a breach of regulation, or some personal danger, and the employer hears of them, he must take what action he can to stop them. The unskilled man needs supervision as well, and the employer who does not ensure at least regular visits to the site would run the risk of being found liable in the case of accident, as well as open to a criminal prosecution if the workman in spite of instructions failed to comply with statutory regulations. The employer renders himself liable even after devising a safe system if he knows or deliberately shuts his eyes to the possibility that the men are contravening instructions or taking risks on their own initiative.

The system of work, though, is a matter which poses few problems for the employer in comparison with the problems of the safety of premises. If he knows his men are careless, he may order them to stop. If he knows that the premises of his customers are unsafe, on the other hand, he cannot always take action directly, but is obliged to change his own system of work for his men. The problem arose in a particularly unfortunate way in a case before the House of Lords eight years ago, which illustrates clearly the dilemma of the employer, as well as his liability. A welder was employed by sub-contractors on work on a ship under repair. The staging was inadequate, as was obvious and known to both the welder and his employers, and representations were made to the repairers, who were "in occupation" of the ship, and thus responsible for such matters. Nothing was, however, done, and the welder fell and was injured. He sued the repairers and was unsuccessful before the House of Lords : the danger was obvious, and the "occupiers" of the ship had at that time (the law has been changed a little since) no duty to do more than ensure that the danger was known to the workman. There was an indication in the judgments, though, that the welder would have had better success against his employers, the sub-contractors, if he had sued them. Their duty, hinted the House of Lords, and this has just been reiterated in the recent case first discussed, is to safeguard their own men from dangers, and if their representations to the occupiers of the premises do not ensure this, then it is the employer's duty to withdraw his men.

† Cilia *v.* H. M. James and Son, 1954, 1, W.L.R. 721.

Britain's Contribution to the Deterrent

By OUR NAVAL CORRESPONDENT

A new White Paper on Defence was published on Tuesday. This article by our Naval Correspondent sums up the existing defence situation as he sees it. The article appears here, rather than in some more popular journal, because weapons are primarily produced by engineers and what weapons are produced is decided on the basis of defence policy.

"THERE is at present no means of providing adequate protection for the people of this country against the consequences of an attack with nuclear weapons . . . a proportion of bombers would inevitably get through. Even if it were merely a dozen, they could, with megaton bombs, inflict widespread devastation."

The above extract from the 1957 Defence White Paper is no doubt familiar to all readers of this journal. But writers on naval policy and strategy would be wise to attach more weight to it. Not only are the British Government's defence measures based on it. It also governs the minds of the masses who now rely on the Government to prevent war while they themselves concentrate on their lawful occasions. They do not believe that, under present conditions, wars will continue to end by the victor's domination of the sea and their physical occupation of the territory of the vanquished. Ruins may be admirably adapted for defence by a stubborn foe. But the British people feel that, even with the 1940 spirit, they would be in no condition to take much further part in a war after the destruction of all their factories and the vast majority of their homes, with the surrounding air made dangerous with fall-out.

If naval enthusiasts are to influence editors and other influential persons who think about the defence of their country and, above all, our Members of Parliament, they would do well to begin by pointing out the change in the defence outlook since N.A.T.O. was organised over ten years ago. The functions of our fighting services—and in particular the Royal Navy's function—and the weapons they would require in the event of a major war can only be explained convincingly in the light of that change.

No time need be spent in stressing the Royal Navy's obvious deterrent value in "bringing power rapidly to bear in peace time emergencies and limited hostilities." Nevertheless it is unfortunate that during the past year this has too often been referred to by Government spokesmen as the Navy's primary function. The war that really matters to the taxpayer is a war in which his own safety is at stake. As long as British carriers and cruisers are fit to steam, he will not be encouraged to provide money for new ships to fight, say, the Hottentots.

It will be recalled that N.A.T.O. was founded over ten years ago to prevent Russia continuing to absorb one European country after another. N.A.T.O. succeeded because of the United States A-bomb deterrent. But when the East not only possessed nuclear but also thermo-nuclear weapons, it soon became obvious that a war in Europe would mean the virtual extermination of both sides. Only the defence of a vital interest would make it worth while for either side to risk annihilation

While the Western nations have made it clear that their vital interest is their freedom and way of life, the Soviet leaders have yet to be convinced that Germany will not again become a great military power within the N.A.T.O. orbit. To prevent a war of revenge by Germany, is in fact, one of the very few vital interests which Russia seems still to have in Europe ; and her attention is now mainly directed to the underdeveloped countries overseas.

Nor are the N.A.T.O. Governments—particularly the United States Government—yet convinced that the Soviet leaders to gain their ends might not think it worth while to make a sudden, surprise H-missile attack. Both East and West are, therefore, not only building up stocks of A- and H-missiles. They are also taking vast and expensive measures to ensure that their retaliatory power cannot be destroyed or seriously reduced by surprise attack. Moreover in envisaging an attack of this kind, the United States—apparently ignoring the vulnerable position of Great Britain—anticipates a "broken-back" period of warfare and is providing herself with conventional forces of immense size and power.

It is true that a substantial portion of American naval strength is intended as a supplementary or, if need be, an alternative deterrent. Indeed, the United States naval authorities are now requesting funds partly to arm their new nuclear-powered cruiser and some of their existing cruisers with the "Polaris" missile. But from the number and types of their ships, they clearly expect having to safeguard supplies to Europe from attack by Soviet cruisers, armed raiders and submarines. Given the H-bomb war which the N.A.T.O. Governments still regard as the kind of major war to be feared, it has yet to be explained why Britain and the United States differ in their views on the likelihood of a "broken-back" period—a difference evident from the negligible British large-ship contribution to N.A.T.O. of two carriers and two cruisers. It is no answer to point out that "the Royal Navy will be fighting with allies." The United States already bears the primary responsibility for preventing war and she cannot also be made responsible for defending British trade in the wide oceans should the deterrent fail.

It may well be that the 300-odd Soviet oversea submarines also suggest a "broken-back" period. In this connection high-ranking Russian naval officers confirm *Jane's* information that they are now building nuclear-powered submarines (though too small to carry ballistic rockets). It seems, however, far more likely, in view of the new direction in Soviet foreign policy, that the Russian leaders envisage the possibility of a large-scale maritime war fought outside the Continent of Europe and developing from a local campaign overseas.

A war of this kind is not difficult to imagine after a "Hottentot" submarine has torpedoed a British or American warship. Retaliatory and counter retaliatory measures could possibly follow on an ever-increasing scale, until Russia eventually came into the open and began to endanger the Atlantic lifeline. N.A.T.O. leaders—still thinking of a thermo-nuclear war—admit they may have insufficient forces to protect the Atlantic lifeline. But the possibility of a war outside the Continent of Europe endangering that lifeline is dismissed with the argument that one should then resort to the H-bomb. But who would decide when the time had come to commit suicide? In the two world wars nearly three years elapsed before the danger point was reached.

Turning from policy to ships and weapons, the majority of the British nation supports the Government's view that Britain must contribute a share of the deterrent, no matter how powerful the American deterrent may be. But in the light of our financial situation, of Russia's success in launching and guiding her earth satellites and lunar probes, and of the now universal realisation that a thermo-nuclear war means suicide, Parliament might well review the types of deterrent missiles best suited for this country.

Two missiles are at present under development in Britain—an air-launched guided powered bomb ; and a land-based ballistic rocket of semi-intercontinental range, with a "hard," underground site costing a great deal of money. Figures from America give the cost of one of her intercontinental rockets undergoing test as £700,000, whereas the cost of a launching base for a squadron of nine of these missiles is estimated at several millions of pounds. Under the concrete launching sites there must be substantial lengths of piping and pumps for liquid nitrogen, hydrogen and oxygen. Protection has to be provided for sensors, recorders, computers and other instruments. Generators for electrical power, hoists and elevators have all to be placed under shelter.

Unofficial American reports suggest that Intercontinental Missiles can be relied on to land only within 15 miles of the target instead of within the 5 miles required to damage a "hard," or well protected site. Soviet rockets, to judge from recent events, are more accurate. The Americans have successfully tested their 500-mile air-to-surface guided missile "Hound Dog" and it is now in production. Similar missiles of greater range are under development. Only the Minister of Defence and his advisers have the technical knowledge to evaluate the various new missiles under development in this country. But might it not be more profitable to concentrate on the air-launched ballistic power bomb than the land-based ballistic rocket ? A V-bomber with near sonic speed flying at 70,000ft and launching a guided missile 500 miles away from the target should be reasonably safe from enemy anti-aircraft measures.

The possibility of using the relatively small (28ft) "Polaris" missile from ships as an alternative supplement to the V-bomber also needs consideration. Though the main danger at sea now comes from above and below the surface, powerful self-contained units are still required to protect a carrier from surface ship attack when her aircraft have been despatched on a mission ; and to identify and deal with an armed raider reported by aircraft 100 miles away from their carrier. The tendency to denigrate ships of cruiser type is regrettable. Surface ship actions will not be won by the anti-aircraft guided missile but by aircraft and/or guns. Until Soviet surface ships no longer threaten the sea routes, it would seem to be premature to consign the cruiser, like the battleship, to the scrap-heap.

It is technically practicable to build our new ships with a gun armament forward and a "Polaris" and anti-aircraft armament aft, though they would need to be larger than the "Tiger" class to carry such an armament. The Royal Navy would then resume its traditional role of helping to preserve the peace of the world—a role which would in no way prejudice its primary function of safeguarding the sea routes in the wide oceans. There seems good reason to believe that by the time our present five-year defence plan comes to an end the "Polaris" will have the 1500-mile range required to reach all important targets in eastern Russia and that its size will enable it to take the present megaton warhead. Since every large warship must have anti-aircraft and anti-submarine protection, submarines would no doubt provide the safest deterrent of all. But these 5000–6000-ton vessels are at present each costing the United States £38,000,000 and this country cannot afford vast sums for ships primarily—indeed, solely—intended to act as a deterrent.

In conclusion it must again be emphasised that if Members of Parliament and others who think for the public are to be influenced by naval writers, the defence position must be discussed in all its aspects. It may then be possible to persuade the nation that despite the H-bomb, the shield and safeguard we have had for the past 400 years is still the Royal Navy.

Some Trevithick Addenda

By T. R. HARRIS

SINCE the publication of the Centenary volume *Trevithick the Engineer and the Man*, by Dickinson and Titley in 1934, some additional information regarding Trevithick has come to light. Although of a fragmentary nature it nevertheless is of great interest as it is contained in letters written by various persons to his brother-in-law, Henry Harvey of the Hayle Foundry, during the period 1829–32, and some notes of the trial of 1828 concerning the Quays, &c., at Hayle.

Readers of the biography will recall that on page 223 it is stated that in 1828 a company was formed in London for carrying out the drainage of parts of Holland and that Harvey and Co. of Hayle received orders for the construction of an engine to Trevithick's designs.

From a letter dated January 10, 1829, and signed Lucus and Ewbank, we learn that Harvey had "engaged to make Mr. Trevithick an Engine for Three Hundred Pounds." "On its completion," they wrote, "we will allow you to value on us for this amount, but we wish you clearly to understand that we do not consider ourselves liable for any further charge whatever, as this sum is calculated not only to cover the cost of the Engine, but also all charges for its erection in your lighter, expenses attending the experiment, & subsequent taking down and delivering on ship board for exportation."

Then, on April 2, 1829, one Thomas Toy, writing from the Columbian Mining Office, 147, Leadenhall Street, London, inquires: "Pray are you doing any thing for Mr. Ewbank and Mr. Schneider, with respects to Trevithick's project of Draining in Holland? The Parties are very respectable, and you are quite safe in doing business for them to any extent. I state this for your guidance, notwithstanding, I have separated from them, or, rather, they have parted with me. The fact is, that Trevithick made an ample provision for himself, out of the Profits, but, notwithstanding, I introduced him to those Gentlemen, he totally neglected me; and as to Mr. Ewbank, who drew up the agreement with Trevithick, I thought that he felt equally disposed to overlook my claims to some remuneration for my trouble . . . ."

Later in the year, Mr. J. O. John, solicitor, of Penzance, wrote a letter on December 31 which is of interest in connection with that printed on page 335 of Volume II of Frances Trevithick's *Life* of his father. "I had," wrote John, "some conversation with Mr. Praed yesterday on the subject of the proposed improvements at Hayle and I have promised to procure thro' yourself for Mr. Praed a plan of the Harbour and a report from Mr. Trevithick of what he may suggest as effectual for obtaining the desired objects in view. Mr. Praed is anxious to procure these for the purpose of laying them himself before Mr. Telford and he will then make some arrangements for his (Mr. Telfords) visiting the spot in the event of Sir Jno. St. Aubyn joining Mr. Praed in defraying such part of the expense as you may not feel yourself called upon to pay."

The next letter of interest is from Davis Gilbert. It is dated Eastbourne, April 8, 1830, and should be read in conjunction with that printed on page 363 of Volume II of the *Life*. Addressed to "Henry Harvey, The Foundry, Hayle," it reads: "Dear Sir, I have come here during the Easter recess as it is called, and seeing my four hot Houses almost completed, I am naturally induced to enquire about the Hot water apparatus that you have been so kind as to undertake for me.

"I have seen Trevithick, and he told me that he delivered it on ship board for London, but that can hardly be the case without my receiving advice.

"I really do not know how Trevithick is going on. He talks of raising large sums of money, but I fear that he left Hayle in a very unsatisfactory manner. It is impossible for me not to bear him much good will, and the more so now that his health seems to be gone and his strong constitution broken down."

During May, 1830, Thomas Rawlings was in London on behalf of Henry Harvey in connection with the dispute about the quays at Hayle and other business. Writing on the 6th, he reports, *inter alia*: "I have seen nothing as yet of Capt. Trevithick but shall enquire him out to-morrow."

Then on the 8th he wrote: "I yesterday fell in with Capt. Trevithick in Cheapside he is tolerably well but has suffered a great deal from spitting blood and is not now quite free. He has been directing his attention to the coal discharging engines, such as the one now at the Foundry. He has attended the Corporation of London Coal Committee and a Committee of the House of Commons as well as at the Bar of the House on this subject (notice for such attendance he produced to me) and is now daily expecting to be called before the House of Lords on the same subject. He tells me that he has made it appear to them that a saving of 3/6 per chaldron can be saved and the average annual imports amount to 15,000,000chs. He has asked 135 Gues. each for 800 engines and he thinks he shall succeed. He is undetermined whether he shall go to South America, Holland, or France, being applied to from each of these places. Where ever he goes, however, he says he is determined to put Mrs. Trevithick with him. He is now living at Lauderdale House, Highgate, the town not agreeing with his constitution."

Six days later, on the 14th, Rawlings reports: "I found Capt. Trevithick at Mr. Gilberts, he is still very unwell, indeed he sd he is still undecided as to his future movements." Then on the 17th he wrote: "... of this I am sure Capt. Trevithick would not do anything in our favour."

The reason for Trevithick's attitude to his brother-in-law is found in a letter from Robert Follett dated Temple, August 2, 1830. In this he writes: "I yesterday saw Capt. Trevithick having the day before called on him at Highgate without being able to find him. I am sorry to say, however, that we shall derive no assistance from him. I find him extremely irritated against Mr. Harvey, principally as far as I could discover because he had not received his fees for the model and attendances on the trial, etc. He threatens to go down as a witness on the other side and said he would write Mr. Edwards by last nights post, but at last I got him into a better humour, and he does not intend to do so at present. He says if Mr. Harvey wants his assistance he ought to write to him—& that if he will send him up his fees which he calculated for 37 days at 5 guas a day, and will write a letter of apology, he may do what we wish him. These terms I take it Mr. Harvey is not very likely to accede to, but I hope in the meantime that Trevithick will forget the whole matter."

Some rough notes of the evidence offered at the trial of 1828 contain the following information: "Richard Trevithick of Hayle, Brother-in-law of the Plaintif Harvey is a Civil Engineer by profession, was the engineer employed in driving the Tunnel under the Thames. Has obtained several patents for Inventions." In his evidence he stated that he had known the spot in dispute "upwards of 30 years," that he resided at Hayle, or in the neighbourhood, for many years, and has seen the effect of the floodgates. That about fifteen years ago he left the country for South America and "is late returned from there," and was surprised to see the great alteration in the course of the river, which could "be illustrated by an inspection of the model."

In the letter of May 8 quoted above the possibility of Trevithick going out to South America was mentioned. That the idea was seriously entertained is suggested by a letter dated Holywell, January 3, 1831, and written by one Thomas Bratt, to Henry Harvey.

In the course of this letter he writes: "Having been informed of your brother, Capt. Trevithick, forming a Company to work mines in S. America he will consequently take out with him some assistant men." The writer then solicits Mr. Harvey's assistance to procure a situation for his son who had "a desire to visit the American Continent particularly under the direction of Capt. Trevithick."

Diesel-Electric Locomotives for Sudan Railways

High temperatures, humidity, and severe dust storms are among the conditions which had to be met in designing these locomotives for operation in the Sudan, and charge air cooling is one of the measures adopted to give the required engine performance. Rheostatic braking saves wear of brake blocks and tyres when working down the long gradients to the coast with heavy trains conveying the cotton crop.

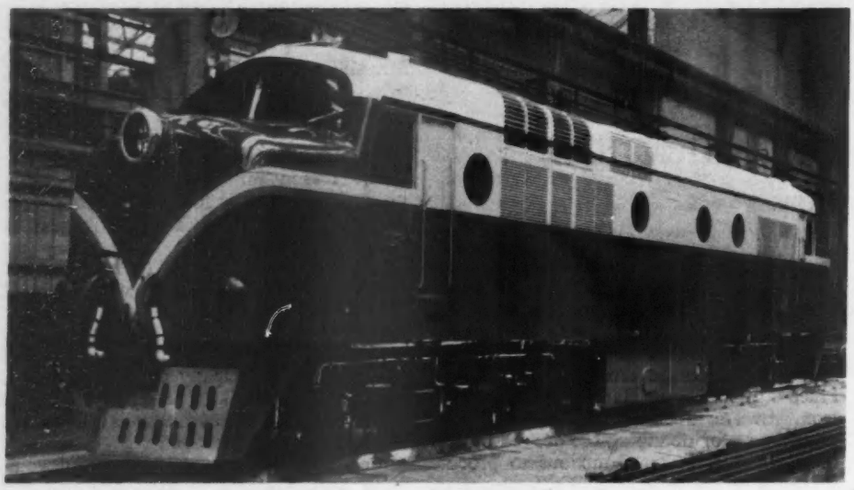


Fig. 1—The second of fifteen 1850 h.p. locomotives now being delivered to the 3ft 6in gauge Sudan Railways

SHIPMENTS have begun of fifteen main-line diesel-electric locomotives ordered from The English Electric Company, Ltd., last year by the Sudanese Government, for service on the 3ft 6in gauge Sudan Railways. The locomotives are the first to be equipped with the English Electric 12CSVT engine with charge air cooling and matched pressure charger. This power unit is capable of developing 1850 h.p. at 850 r.p.m. at site, where maximum altitude is 3035ft and maximum shade temperatures of the order of 120 deg. Fah., with a relative humidity of 47 per cent, have been recorded. An engine identical with that mounted in the Sudan locomotives has successfully undergone the 100-hour type test in accordance with B.S.S.2953, each eight-hour cycle including two hours at 2063 h.p. The test engine has been demonstrated at 2300 h.p. on the test bed.

Fig. 1 shows a completed locomotive at the works of the Vulcan Foundry, Ltd., where the mechanical parts are being built and erection undertaken. Wheel arrangement is C_0–C_0, and the weight of a locomotive in working order 98·75 tons. One of the major tasks of this class will be the haulage of cotton trains of up to 1500 tons from Khartoum and the interior to Port Sudan for shipment overseas. Long, continuous down grades have to be negotiated on the service, and the locomotives have therefore been fitted with rheostatic braking. The brake resistors are in two groups, each with its own motor-driven blower, and are combined in a single roof-mounted unit, the location of which is shown in Fig. 1 by the large louvres in the roof behind the leading cab. Fig. 2 shows one of the units, for which the resistances and the blower fans were supplied by The Expanded Metal Company, Ltd. Overall height of the locomotive is 13ft 5in. During an inspection at Vulcan Foundry on February 11 the latitude allowed by the Sudan Railways loading gauge was emphasised by comparison with British Railways type 4 locomotives under erection nearby, particularly with respect to the liberal roof section and the roominess of the end nose compartments, each of which houses a "Tornado" traction motor blower and an exhauster, both electrically driven.

The radiator consists of two 6ft 6in Spiral Tube panels through which air is drawn by a fan driven by a vertical shaft through a gearbox from which the compressor drive is also taken. The charge air cooling water, after passing through the after-cooler, is fed through a heat exchanger in which the engine lubricating oil is cooled. Thus one water circuit caters for both duties. The engine jacket cooling system forms a second and separate water circuit.

Two motor-driven fans drawing air through louvres and filters high in the body sides pressurise the engine compartment. Air is exhausted from the body by a transverse duct to avoid the disturbance of dust and sand which would be caused by a downwards exhaust. The fuel tank in the centre of the underframe has a capacity of 1600 gallons and is equipped for either gravity or pressure filling. Other constructional features pointed out during the inspection of the locomotive included the use of tubular members for the body side frames, and the lightweight fabricated aluminium roof structure.

The swing bolster bogies are similar to those of the English Electric diesel-electric locomotives for Malaya which were also built at the Vulcan Foundry. Each is fitted with three axle-hung, nose-suspended traction motors carried on the axles by plain sleeve

Fig. 2—Roof-mounting unit containing rheostatic braking resistances and blowers

suspension bearings. Electrically, the six motors are connected across the main generator in three parallel circuits of two motors in series. Tractive effort at the continuous rating is 48,000 lb at 11·6 m.p.h., and maximum service speed 45 m.p.h. Starting tractive efforts are 63,000 lb maximum or 55,300 lb at 25 per cent adhesion. Wheel diameter is 3ft.

All the electrical control equipment and resistances (except for the braking resistors mentioned above) are contained in a T-shaped cubicle fitted in the rear wall of one cab and extending a short distance into the engine compartment. The load regulator takes the usual English Electric form of a rotating arm operating contacts by means of a roller, but the previous electric motor drive has been replaced by an oil-operated vane motor. Two steps of traction motor field-weakening are introduced through contacts in the regulator at the maximum excitation end of its travel and these are taken immediately, without a backward movement of the regulator. Any momentary overload is rapidly compensated by the normal regulator action, and it is felt that this scheme has an advantage over one in which the weak-field contactors do not close until generator excitation has been reduced, since in rapidly changing load

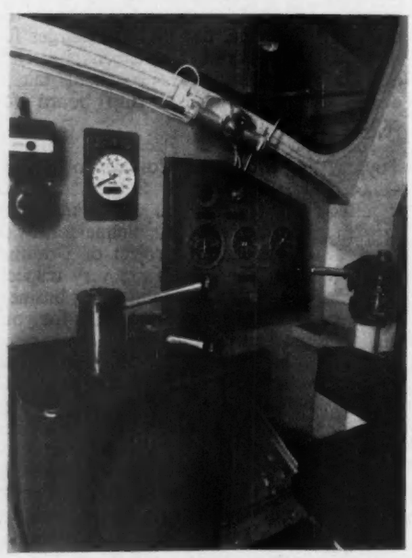


Fig. 3—Driving position, showing the combined power and rheostatic braking control lever and wheel-slip warning bell

conditions this delay may result in further motor field control being required by the time the first step has been taken.

The two weak-field steps are obtained by diverter resistances switched by electro-pneumatic contactors. Restoration of full field is controlled by a current relay. Wheel-slip is detected by relays, connected between the mid-points of the motor circuits, which cause engine speed to be reduced (but not necessarily to idling) until slipping stops. A bell warning is provided so that when two locomotives are working in multiple the driver of the leading unit may know if the second locomotive is slipping, and notch back on his own controller if it continues.

The cab layout is shown in Fig. 3. Power and braking are controlled by the upper controller lever, and changes from one mode of operation to the other require no other manipulation than the movement of this lever to the appropriate sector of its travel. For power control the lever effects continuous acceleration of the diesel engine through a self-lapping air valve and the governor speed-setting system, engine revolutions per minute being proportional to the lever displacement. For braking, the lever is moved in the opposite direction and is normally manipulated between a "lap" position which maintains a constant excitation, and "increase" or "decrease" positions, which adjust the generator excitation through the load regulator. In these conditions the diesel engine runs at idling speed and the generator output is applied to the traction motor fields. The braking resistance blowers operate automatically, being connected across their respective resistances.

The lower controller lever is released by the control key and may be moved to an "engine only" position which enables the engine to be run and accelerated without moving the locomotive. From this position it is operated to set the reverser.

The main ammeter has a centre zero and shows traction and braking currents in opposite sectors of its scale. On both sides the scale is coloured green from 0A to 600A and red from 600A to 800A as a warning against maintaining heavy currents. A general fault indicator on the panel is normally blank but displays a number of white segments (illuminated at night) when a fault occurs. This arrangement has been adopted because the usual dim or bright lamp signal would be insufficiently distinctive in bright sunlight. Two flag indicators on the rear cab wall identify the fault as high water temperature or traction motor blower failure. Fire warning is given by bell.

If necessary the electrical connections of the locomotive can be changed at a depot to enable the braking resistances to be connected across the generator as an artificial load for engine testing.

Hook Road Underpass

THE Hook Road underpass, a junction on the Kingston By-Pass in Surrey, was opened last Friday by Lord Chesham, joint parliamentary secretary to the Ministry of Transport. It is especially worth noting at this stage in the national road programme that this two-level junction is only the second of its kind in the London area.

On most days 25,000 vehicles use the Kingston by-pass at its junction with Hook Road (A.243). At morning and evening peaks and for long periods at summer week-ends, the traffic rises to 3000 vehicles an hour. The new underpass is designed to take 6000 vehicles per hour "with ease and in safety," according to the Ministry of Transport. At ground level there is a large elliptical roundabout. Two prestressed concrete road bridges are connected by four slip roads to the trunk road, which runs under the roundabout between 25ft high retaining walls. The illustration shows the dual carriageways of the trunk road, one of the roundabout bridges, and part of the slip roads; 84 per cent of the traffic will now travel along the carriageways illustrated here. A steel pedestrian bridge goes over the by-pass east of the junction. On the London side of the junction the existing dual 30ft carriageways narrow to 24ft through the underpass and 22ft slip roads, one on each side, connect with the Hook Road roundabout. On the Esher side the present 30ft single carriageway is now to be replaced by dual 30ft carriageways as far as Woodstock Lane, which will give a continuous stretch of dual carriageway for nearly 4 miles when this work is completed.

The dimensions of the site and the frontage properties imposed severe restrictions not only on the layout of the scheme but also on the actual work of construction, which was further complicated by the very heavy volume of traffic on the by-pass and the Hook Road throughout the construction. The walls forming the sides of the underpass were constructed in deep trenches whilst the trunk road traffic was maintained on the existing carriageway in the centre. As soon as these walls were completed and the four slip road carriageways constructed, traffic was diverted from the centre to the slip roads on each side of the underpass, thus enabling the bridge works and the excavation between the underpass walls to be carried out. Sulphate-resisting cement was used in the walls and bridge foundations.

To prevent ice forming on the slopes of the underpass, thermostatically-controlled electrical heating cables are laid under the asphalt wearing surface of the road through the cutting. This is an experimental installation, carried out by the Ministry with the Road Research Laboratory, to test its effectiveness on the gradients which steepen to 1 in 28 for a short distance on the London side.

Lighting in the underpass is also automatically controlled and is switched on by a photo-electric cell device. There are sodium lanterns on reinforced concrete columns, but some of the lanterns are built into the retaining walls. In the deeper parts of the underpass flush wall-lighting fittings have been installed.

As an additional safety measure, a barrier of flexible steel beams has been installed along the whole length of the central reservation through the underpass.

The construction of the underpass has taken just over seventeen months and had to interfere as little as possible with normal traffic. The main contractor is William Old, Ltd., and the works were designed by Mr. D. S. Samuel, M.I.C.E., county engineer to the Surrey County Council which is the Ministry's agent authority for the scheme. The cost of the underpass was about £400,000.

Carriageway Heating

The object of the heating experiment has been to develop a method of providing heating elements in an asphalt carriageway which will enable the surfacings to be laid at an economical cost and at a speed comparable with that now expected for such work. Successful experiments in the heating of carriageways have already been carried out in other parts of the country, The method adopted at this underpass has proved that, with a rubber-tyred mechanical spreader for the blacktop material, the speed of laying the surfacing material need not be unduly restricted.

The heating elements consist of well-insulated wires placed 3in below the carriageway surface. The energy consumption of the elements is about 80W per square yard of carriageway. Thermocouples, consisting of copper and constantin wire are placed in the asphalt ½in below the surface. The surface wetness of the carriageway is measured by brass strips a few inches apart, inserted in the surface. The electrical resistance between these two brass strips is affected by the amount of moisture on the carriageway surface.

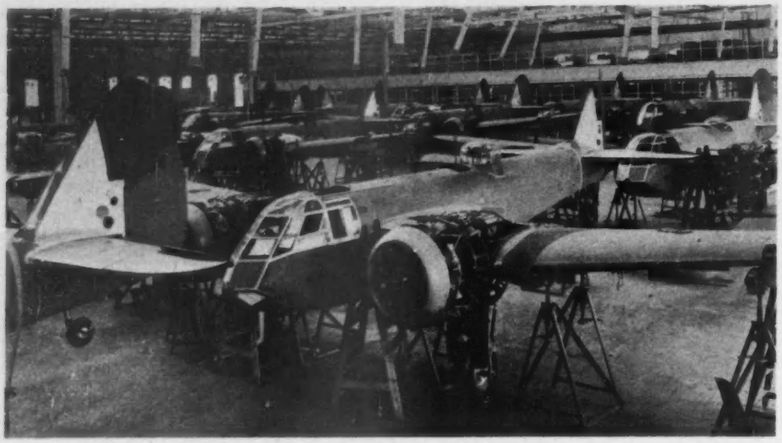
The net effect is that the heat is switched on when the carriageway surface is wet as soon as the temperature falls below 36 deg. Fah. If the the carriageway surface is dry, then the heat is not switched on until freezing point is reached. A somewhat similar apparatus for registering temperature and surface wetness is fixed clear of the carriageways but near the control building, and is so designed as to give advance warning of excessive condensation on the carriageway surface and also to act as a snow-detector, thus causing the heat to be switched on under these special conditions. Air temperatures are automatically recorded in the small white boxes on the central reservation approximately 3in and 3ft above the roadway, as a means of indicating whether a frosty period is approaching or ending. The heat generated is sufficient to melt snow at the rate of about 1in depth of snow per hour. The whole of the electrical arrangement has been designed to operate on the off-peak tariff, and the running costs in a normal year are anticipated to be in the neighbourhood of 2s. 6d. per square yard of carriageway.

The total installation is 360kW, installed by Kingston District contracting and mains departments staff, and is made up of 120 heating cables each of 3kW loading and manufactured by Aerialite, Ltd. The cables consist of an enamelled copper alloy conductor insulated with polychloroprene and sheathed with p.v.c. The length of each cable is 653ft, giving a loading of 4·5W per foot.

The cables are laid on a base course of rolled asphalt and are spaced at 6in centres by plastics spacer bars. The spacer bars are fixed to the asphalt base by clips secured by nails driven into the asphalt.

Engineering Jubilee at Bristol

To-day is the fiftieth anniversary of the founding of The British and Colonial Aeroplane Company by Sir George White, Bt., with a capital of £25,000. The products of that firm and its successors have been prominent in the history of aviation and of this country; the first recorded military heavier-than-air flight was made by a "Boxkite," while in the Great War the "Scout" and, particularly, the two-seater "Fighter" earned fame, both being designs of Capt. F. S. Barnwell. After the war the firm was named The Bristol Aeroplane Company, and in 1920 it acquired the Cosmos Engineering Company, builders of air-cooled radial engines. The use of direct air cooling predicates very complete control of the air flow if satisfactory net thrust is to be realised. An early

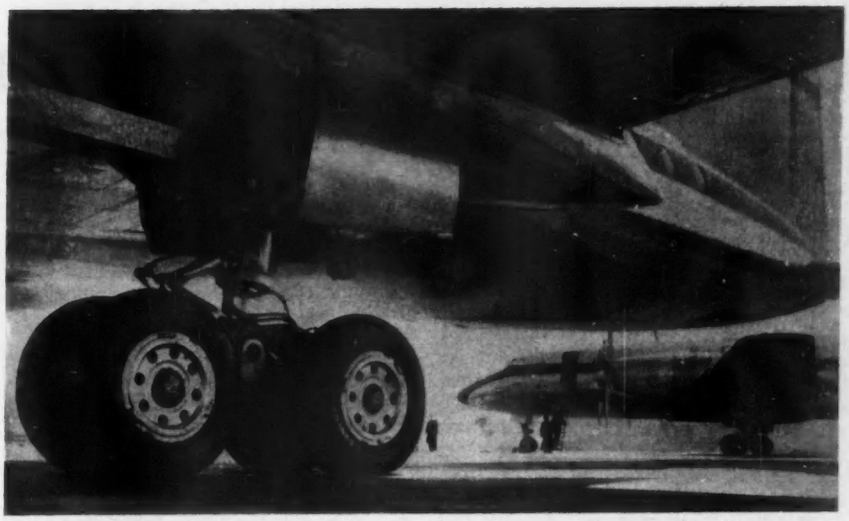


example of this theme is seen ABOVE on the Type 72 racing monoplane, with a ducted spinner and full cowling for the 436 h.p. "Jupiter" IV; the stub exhausts protrude through the cowling. The fin and rudder have a profile that was to remain recognisable until the "Buckingham" and "Brigand" displayed fins in each slipstream. The 72 was never cured of aileron reversal attributable to inadequate wing stiffness. Another single-seat monoplane, but with a fixed undercarriage, the Type 138, twice broke the heavier-than-air altitude record in the years immediately before the last war; it was powered by a highly supercharged "Pegasus" engine, other versions of which saw extensive civilian service. With the same cylinder dimensions but a smaller overall diameter, the "Mercury" was intended for military use, but two were used in a light transport for Lord Rothermere, the Type 142 "Britain First," which proved itself some 50 m.p.h. faster than the fighters of the R.A.F. The bomber that stemmed from this origin, the "Blenheim," is seen LEFT, in production in its Mark I form; notice the close cowling of the engines.

The "Blenheim," used principally as the Mark IV with extended nose for the navigator/bomb-aimer, was supplanted by the even faster "Beaufort" torpedo-bomber with twin fourteen-cylinder sleeve-valve "Taurus" engines, from which evolved the "Beaufighter," with a pair of "Hercules" engines. This machine remained for year after year the most heavily-armed fighter in service, having a fixed gun complement of four 20mm cannon, to reload which was the duty of a second crew member behind the wing, and six rifle-calibre Browning guns. The airframe afforded an excellent gun platform, allowing kills to be made at such a range as not to imperil the machine, while the disposable load could include bombs, rockets, or a torpedo. A.I. (Airborne Interception) radar was carried in the night-fighter role, while the high fuel economy and relative immunity to damage of the air-cooled engines allowed successful patrols across the Bay of Biscay. The machine RIGHT is the last of over 3000 built at Weston-super-Mare

After the war, radically new products were undertaken. Single- and tandem-rotor helicopters were built, for which poppet-valve radials and small gas turbine engines were purchased. By far the biggest project undertaken, however, was the "Brabazon," designed to carry passengers across the Atlantic non-stop in luxury; grossing 290,000 lb, it is still the largest landplane ever built in this country. The prototype, seen LEFT, had eight "Centaurus" engines driving four contra-props through individual transmissions; however, the firm had always striven for engines of the largest power and consequently had diverted much of its effort to turbine power plant. The first such project, the "Theseus," followed the Bristol tradition of emphasising fuel economy to the extent of being designed for a heat exchanger. For the "Brabazon" there was developed the "Proteus," which takes after the piston engines not only in offering high power and long life, but also in being comparatively short and fat; two are seen installed in an Avro "Lincoln" flying test bed LEFT.

Before a "Proteus"-powered "Brabazon" had been completed the company diverted its efforts to the four-engined "Britannia," which in transatlantic service grosses 180,000 lb ; however, before the development of even this smaller machine was completed piston-engined airliners had been developed to perform scheduled non-stop transatlantic flights. The shorter, earlier versions, used on the Empire routes, were the first turbine machines to enter many latitudes in commercial service, and it fell to them to show that the standards of ice toleration established from experience in the northern hemisphere were inadequate. Six international airlines use the "Britannia," which is the only British airliner ever to be in service all round the world ; at present utilisation is over 3,000,000 miles a month of revenue flying. This machine introduced the bogie undercarriage to commercial service (RIGHT), and to meet United States requirements the bogie was modified to tolerate pivot turns. Derivatives of the "Britannia" include the Canadair "Argus" with Turbo-Compound engines and the CL-44 and Short "Britannic" with compound turbines.



After the war, there was commenced the manufacture of a version of the B.M.W. 327/80 with the 1971 c.c. in-line water-cooled poppet-valve engine and a fixed head coupe body. A special body built by Farina inspired the highly aerodynamic "401," built on aircraft principles in light alloy, seen LEFT. Still with the same sized engine, the speed went up to over 100 m.p.h. in the "403," while for Frazer-Nash competition cars up to 140 h.p. was made available. To-day, however, the cars are available only with coach-built bodies ; the engine has been bored out to displace 2216 c.c. Another change is that the rear axle is located laterally by a Watts linkage instead of an "A" bracket in order to give some choice of roll centre height, but otherwise the B.M.W. layout is retained, there still being an open propeller shaft. Distinctive details of the design are a free-wheel in the first ratio of the four-speed transmission and a built-in chassis lubrication system.

Another new product is guided weapons. To provide an expendable air-breathing engine, Bristol, with co-operation from Boeing, developed a supersonic ramjet, the "Thor," two of which power the "Bloodhound" long-range anti-aircraft weapon. This missile is virtually a supersonic unmanned aeroplane, manœuvring in the twist-and-steer manner by moving the monoplane wings; however, it is confined to point defence by a semi-active guidance system. The four solid-propellant boosters seen on the example at RIGHT are also Bristol products, while Bristol Aerojet, Ltd., are building both solid- and liquid-fuelled rockets. The construction of free-turbine engines led naturally to compounds, and the "Olympus," which followed the example of the "Pegasus" in achieving heavier-than-air altitude records, is the only British compound engine yet to see service. A compound propeller-turbine, the "Orion," was discontinued on the grounds that the expense of developing it was not warranted (so that heavy military turbo-prop transports are now being provided with separate engines for boundary layer control) but ducted fans of closely related thermodynamics are now in course of construction. Unusually, a small engine is also offered to-day ; the "Orpheus" turbojet originated from the high-pressure line of the "Orion." An interesting machine at present progressing towards its first flight is the stainless steel Type 188 supersonic research aircraft ; this, however, does not have Bristol power plant and is severely thrust limited.

It has been observed, not least by Bristol, that the optimum design of a high performance aeroplane requires integration of the airframe and engines. Nevertheless, the firm itself has disintegrated : The Bristol Aeroplane Company, Ltd., is to-day a holding company with a half interest in Bristol Siddeley Engines, Ltd., which includes Bristol Cars, Ltd., and a 20 per cent interest in Bristol Aircraft, Ltd., which as well as fixed wing aerodynes makes plastic bodies for cars and motor-cycles.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

TRAFFIC ENGINEERING IN LONDON

SIR,—I was delighted to see your reference of January 15 to the subject we discussed at the Traffic Engineering Study Group on the 21st. The discussion at that time showed that much had been done by traffic engineering methods in London in the past and that, while more no doubt could be done, a great deal was not to be expected from this as a substitute for road improvements which themselves must be designed on proper traffic engineering principles.

The point regarding the eleven different schemes which were worked out for Trafalgar Square was perhaps misunderstood. The best of these was tried and found successful. No time was lost in working the schemes out on paper whereas to have tried the others on the ground would have taken a considerable amount of time although perhaps not much expense. Any traffic scheme must be allowed to run for a while until drivers become accustomed to it. This would certainly have been necessary in those early days.

It is quite clear also from later experience of traffic engineering that most, if not all, of these alternative schemes would have caused considerable congestion as would many that are now put forward without proper traffic investigation.

Surely the Traffic Engineer, like other engineers, should make his mistakes on paper instead of on the ground, even if his mistakes may not be so costly as in some other branches of engineering.

A. J. H. CLAYTON

London County Council,
Chief Engineer's Department,
Westminster,
February 10, 1960.

Book Reviews

Machines à Calculer Electroniques : Arithmétiques et Analogiques. By M. Pélegrin. Dunod—Editeur, 92, Rue Bonaparte, Paris, 6e. Price Fr.4400.

THE fourteen chapters of this book are based on a course of lectures given by the author at the Ecole Nationale Supérieure de l'Aéronautique. A foreword by Pierre de Valroger warns that reading alone may not be enough for a full comprehension of computer practice, but that the newcomer to the subject must be prepared to advance step by step with intervals of reflection on each concept introduced and, if possible, practical exercises. On the other hand, the reader who is already in contact with computer work will find in these pages a valuable source of reference to current practice, and while specific computers referred to are mainly French, the chapters on general principles, fundamental circuits and computer logic are of general interest. Sometimes, however, the conciseness forced upon the author in order to cover his subject in a reasonable space obliges the reader to accept facts for which the reasons may not be fully clear to him. It would seem, in view of the author's own remarks on the vital importance of "and" and "or" gate circuits that their operation might have been explained in greater detail. However, where assumptions such as this of the reader's nimble-wittedness are made, they usually relate to electronic rather than specifically computing techniques so that further information can be sought elsewhere. It is pleasant to note that France has not found it necessary to create a second language for the benefit of computing, or to borrow from other sources, so that terms such as "gate" and "flip-flop," when quoted, are followed by the admonitory parenthesis "anglicisme à éviter." The "flip-flop" becomes a "bascule," a word respectably enshrined for many years in "Larousse" as "a machine with one end which lifts when the other is depressed."

The book is in three sections, the first introductory and setting out the basic definitions. This is followed by Part 1 on analogue computers, and covering as well as electronic machines certain other devices such as the electrolytic tank, mechanical analogues, and those using electrical circuits and servo-motors for certain operations. Part 2 deals in detail with digital machines, their components, programmes and operation, and includes a chapter on the incorporation of computers to form part of automation systems. Some brief but intensely interesting paragraphs describe how a computer might set about translating a French word into the appropriate English equivalent for a particular context. For all his enthusiasm, M. Pélegrin concedes that a computer translation of "Il pleut dans mon coeur comme il pleut dans la ville ; quelle est cette langueur qui pénètre mon coeur," might miss some undertones of the original. Another useful assumption made by the author is that some of his readers may not be familiar with the binary code, and he therefore gives tables of decimal and binary numbers. For some reason, many writers seem to assume that a knowledge of binary code is a kind of original sin implanted at birth, and the less said about it the better. Those who have missed this dubious heritage will applaud the author for supplying the means to make good their deficiency.

Cryogenic Engineering. By R. B. SCOTT. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 42s.

Progress in Cryogenics. Vol. I. Edited by K. MENDELSSOHN. Heywood and Co., Ltd., Carlton House, Great Queen Street, London, W.C.2. Price 63s.

THE rapid growth during the past ten years in low temperature research and the application of very low temperatures to practical purposes in such fields as rocketry and computers has led to the adoption of the new word "Cryogenics." By this word is implied the techniques of achieving low temperatures, the engineering problems involved in designing apparatus to work there, and the practical exploitation of low temperature phenomena.

The content of Dr. Scott's book is influenced by his position as head of the U.S. Bureau of Standards Cryogenic Laboratory at Boulder, Colorado, and it speaks with most force on those subjects which have been the concern of that laboratory. A comprehensive and authoritative account is given of the theory and practice of liquefaction, with special emphasis on hydrogen and helium. Low temperature distillation is dealt with only briefly, and no attempt is made to cover the industrial fields of oxygen production and hydrocarbon gas separation. A brief account is given of cooling by adiabatic demagnetisation. An extremely useful chapter is given to thermometry, a subject in which Scott has made many contributions. Then comes the major topic of the book, which is the piping and storage of liquefied gases, with all the associated phenomena. Both theory and practice are presented, and the wise choice of detail gives confidence to the reader that every point necessary for the achievement of sound design is being disclosed. The book concludes with valuable compilations of physical properties of low temperature fluids, and of mechanical, electrical and thermal properties of low temperature constructional materials. The facilities available to the author, combined with a workmanlike and lucid presentation make the book a most valuable work of reference.

The other book, *Progress in Cryogenics*, consists of nine articles on a wide range of topics by an international team of experts. The range reaches to the bounds of Cryogenics and perhaps beyond, but each article provides fascinating reading with a non-specialist approach. Some of the most exciting developments are reviewed by D. R. Young in an article on superconducting circuits for computers, and by G. J. Minkoff on frozen free radicals. Recent developments in the application of thermoelectric cooling are described by D. A. Wright, but this is very much a borderline subject since it deals only with normal refrigeration temperatures. Present problems of large-scale applications of low temperatures are treated by B. R. Brown in a paper on the separation of gases by distillation and by M. M. Fulk on vacuum-powder insulation. Finally, there are four papers dealing with techniques in low temperature physics, two being on calorimetry by R. W. Hill and N. V. Zavaritsky, and the others being on the measurement of the mechanical properties of metals by H. M. Rosenberg and R. W. Morse. The standard of writing and presentation is high and all the papers are well documented.

Electro-Technology for National Certificate Courses. Vol. 3. By H. BUCKINGHAM and E. M. PRICE. The English Universities Press, Ltd., 102, Newgate Street, London, E.C.1. Price 16s.

PREVIOUS volumes in this series have dealt with the subjects required for the first two years of the Ordinary National Certificate course, with some extensions to increase their usefulness to students preparing for other examinations. Similarly, this third volume approximates in its scope to the third year syllabus but also covers some of the requirements for the electrical engineering papers in Part 2 of the examinations of the Institution of Electrical Engineers.

The book opens with a chapter on d.c. armature windings, and proceeds to the

characteristics, operation and testing of d.c. machines. Subsequent chapters on electric and magnetic fields take the opportunity of introducing devices such as the electron gun, the saturable reactor, and the transductor. A study of the a.c. circuit and resonance phenomena leads to the consideration of polyphase circuits and transformers. Every effort is made to relate theory to modern industrial practice, and so at this stage the student knows something about high-voltage bushings, and current and voltage transformers, and has been shown what some of them look like in practice.

The subject of a.c. motors is introduced in the course of a chapter on rotating fields with explanations of the principles of synchronous and induction machines. It would have been advantageous here to have said something about the single-phase motor, methods of starting it, and how the effect of a rotating field is produced while running. A further circuit theory chapter then deals with network calculations and bridge circuits, both d.c. and a.c. Rectification finds its place in two chapters, the first of which shows the basic circuits, assuming the use of metal or semiconductor rectifiers (the construction of which is briefly described and illustrated) and the second considers thermionic valves and gas and vapour-filled rectifiers under the general heading of electronics. This chapter looks briefly at crystal diodes and transistors and enlarges upon earlier references to the electron gun with an account of an oscilloscope and its timebase. A simple transistor amplifier circuit is shown, but although the authors have previously discussed the characteristics of the triode valve, they have not drawn attention to the difference in input and output resistance with transistors and its effect on associated circuit design. In conclusion the authors discuss some economic considerations of electricity utilisation and supply. Throughout the book they have taken care to equip the student not only for tackling his examination papers, but for his necessary background reading of technical literature.

Design of Welded Pipe Fittings. Prepared by P. H. R. LANE, B.Sc., and R. T. ROSE, B.Sc., Ph.D. British Welding Research Association, 22, Park Crescent, London, W.1. Price 15s.

IN a foreword to this publication Professor H. Ford points out that since its inception the association has been aware of the fact that the increasing application of welding permits, and in many cases demands, a more rational approach to mechanical design than has hitherto been the case. The time-honoured, essentially practical, approach has been to use relatively inexact design methods together with a large factor of safety to cover deficiencies in joints, and, to a great extent, gaps in the designer's knowledge of the stresses acting in complex components. The proper use of welding can eliminate the deficiencies of the joints, but its full economic advantages are not available until there is a better understanding of the stress systems actually arising in the equipment to be designed. Part of the work of the British Welding Research Association has been aimed at supplying such an understanding and this booklet summarises the work carried out on piping components. It gives details of extensive stress measurements on pipe bends, or welding elbows. Von Karman's classical method of calculating the stresses has been extended to be applicable to short-radius and thin-walled bends which have been increasingly used in recent years. The experiments have confirmed the validity of the proposed calculation.

Stress measurements on fabricated branch connections described give a rational basis for a comparison between the effectiveness of various forms of reinforcement currently in use, or proposed for use. A further section deals with fatigue strength of pipe butt joints, and of various designs of end closures for model headers. From this work, important conclusions have been drawn concerning detail design of welds to attain maximum efficiency and the importance of various classes of defect.

Books of Reference

The Ironfoundry Handbook. Standard Catalogue Company, Ltd., 20, Bloomsbury Way, London, W.C.1. Price 42s.—This book is intended to provide a comprehensive guide of the products and capacities of ironfounders throughout the United Kingdom and Eire. It first gives general notes on the organisation of the ironfoundry industry, conditions of sale, relevant data on castings, standard specifications, &c. Producers of iron castings are then listed under ten regional areas covering the country. In these lists, with the name and address of each company there is given the maximum weight and size of casting it can produce on a jobbing or repetition basis, whether it has a pattern shop or a machine shop, and any trade names used for its products. These lists are very useful to potential customers seeking likely suppliers and it is to be regretted that some of the firms do not give details of their products and facilities. Subsequent sections of the book broadly list the industries in which different kinds of castings are used and firms specialising in their production. Brand names and suppliers of foundry equipment are also listed.

Who's Who in the Motor Industry. Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 42s.—The fourth edition of this reference has been amplified with sections on the (British) motor industry overseas, the competition and racing managers, and the one-make car clubs. The part devoted to the industry includes comprehensive lists of manufacturers and suppliers; however, there are no cross-references from manufacturer to distributors, nor is there an index of trade names.

Books Received

Petroleum Refinery Manual. By H. M. Noel. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 64s.

Scientific Russian. By G. E. Condoyannis. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 28s.

Organization of Building Sites. By R. C. Sansom. Department of Scientific and Industrial Research. H.M. Stationery Office. Price 21s.

Powder Cutting and Flame Processing. By Borje Brandstedt. Powder Metallurgy, Ltd., Berk House, Portman Square, London, W.1. Free.

Technischer Strahlenschutz. By T. Jaeger. Verlag Karl Thiemig KG, München 9, Pilgersheimer Strasse 38, Western Germany. Price DM.8.60.

Research Techniques in Human Engineering. By A. Chapanis. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 48s.

Fliesspressen von Stahl. By H. D. Feldmann. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, German Federal Republic. Price DM.31.50

Die Drahtseile in der Praxis. Third edition. By R. Meebold. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, Western Germany. Price DM.12.

Fifth National Symposium on Vacuum Technology Transactions. Edited by W. G. Matheson. Pergamon Press, Ltd., 4 and 5, Fitzroy Square, London, W.1. Price 100s.

Dock and Harbour Engineering. Vol. 2: *The Design of Harbours.* By H. F. Cornick. Charles Griffin and Co., Ltd., 42, Drury Lane, London, W.C.2. Price 126s.

Investigation of the Performance of Pneumatic-Tyred Rollers in the Compaction of Soil. By W. A. Lewis. Department of Scientific and Industrial Research. H.M. Stationery Office. Price 3s. 6d.

Technical Reports

Air-Cooling Methods for Gas-Turbine Combustion Systems. By F. J. Bayley. Reports and Memoranda No. 3110. H.M. Stationery Office. Price 12s.—This paper, dated August, 1951, presents an account of the whole of the work which had been done at the National Gas Turbine Establishment on the problem of air cooling gas-turbine combustion systems. Each of the different methods of wall cooling is discussed separately and the theory and mechanism of the cooling process is developed from first principles. Certain of the methods have been the subjects of experimental investigations and in such cases a brief description of the test arrangements is given and the results are analysed and discussed. Sufficient information is given to enable any of the various methods to be applied to practical wall-cooling problems and, in a conclusion to the report, their relative advantages and disadvantages for different gas-turbine applications are considered. It is shown that "sweat," or effusion-cooling, is by far the most effective and efficient method, while the use of "louvred" surfaces represents the nearest practical approach to this ideal which is possible while suitable porous materials remain unavailable. The remaining methods (convective cooling by external airflow, localised air injection to form a protective blanket of coolant, and a combination of these two) are all less effective, but provide means whereby conventional combustion systems may be conveniently cooled without the need for porous materials or the weight increases associated with louvred walls.

Road Note No. 24. Roadstone Test Data Presented in Tabular Form. H.M. Stationery Office. Price 9d.—The British Standard methods of test for roadstone have recently been undergoing revision. Among the new tests proposed for the revised standard are an abrasion test for aggregates, a test for measuring the resistance of aggregates to crushing in terms of the load required to produce 10 per cent fines from ½in chippings, and a test for measuring the resistance of aggregates to the polishing action of traffic. The accuracy and reproducibility of the method of test for the water absorption and specific gravity, of coarse aggregates have been improved, and the methods for measuring the resistance of aggregates to crushing and impact have undergone minor alterations. When the new standard is issued, it is expected that the results of these newer tests will replace those of the older tests in specifications for roadmaking aggregates.

When new or improved methods of tests are standardised, some means of assessing the results is necessary. One method is to compare a particular test result with data obtained on samples covering the full range of roadstones. These data have now been obtained for the new methods of test, and in this report the data have been summarised in tabular form to provide a standard of comparison. Brief descriptions of the methods of test are given in an appendix; for full descriptions reference must be made to the revised Standard when it appears.

Preliminary Note on the Effect of Inertia Cross-Coupling on Aircraft Response in Rolling Manœuvres. By W. J. G. Pinsker. A.R.C. Current Paper No. 435. H.M. Stationery Office. Price 12s. 6d.—Results from a systematic series of simulated responses to aileron manœuvres are discussed. It is shown that large amplitudes in incidence and sideslip can occur on aircraft having large inertias in pitch and yaw when performing quite modest rolling manœuvres. In general these amplitudes increase progressively with the duration of the rolling manœuvre and with the incidence of the principal inertia axis. The aircraft response deteriorates rapidly as the rolling velocity approaches a value determined by the natural frequencies of the uncoupled lateral and pitching oscillation of the aircraft.

If the incidence of the principal inertia axis is below a critical value an auto-rotational rolling state exists towards which an aircraft tends to diverge once it has exceeded a certain critical rolling velocity. For aircraft with large inertia in pitch this critical value can be as low as about 20 deg. per second. The practical significance of this phenomenon to the pilot is not yet fully understood.

Various alternative schemes of auto-stabilisation have been explored. They require generally very powerful control movements and may not necessarily relieve the tail loads as such.

Good Practice in the Fire Protection of Buildings. Fire Offices' Committee, Fire Protection Association, 31-45, Gresham Street, London, E.C.2. Price 2s.—This report deals with forms of fire resisting construction and the sub-division of buildings. Particulars are then given of structural elements, walls, enclosures, lifts, roofs, &c., incorporating the essential requirements of fire resisting construction. Useful tables include the fire resisting properties of various materials used in construction of buildings.

SHORTER REPORTS

Award of the Kelvin Medal

THE Kelvin Gold Medal for 1959 was presented to Sir Geoffrey Taylor, F.R.S., at the Institution of Civil Engineers last Tuesday. Before the presentation, Professor A. J. S. Pippard, F.R.S., said: "... Sir Geoffrey belongs not to one society alone, however famous, but to the whole world of science and engineering. Sir Geoffrey's versatility led him from early studies of eddies in the atmosphere and an expedition to the North Atlantic in 1913, to aerodynamic research in the first world war, and the elucidation of problems connected with the propagation of shock waves in the earth and the physics of nuclear explosions in the second. His work in meteorology and aerodynamics and his many contributions to hydrodynamics, to elasticity, to the behaviour of crystals under strain, to plastic flow in metals and to the mathematics of viscous and compressible fluids, have firmly established his reputation as one of the greatest of applied mathematicians and mechanicians."

Professor Pippard went on to say that throughout a productive life of over half a century, Sir Geoffrey Taylor had produced a yearly average of three or four original scientific papers of outstanding quality. One volume of his *Collected Papers* containing forty papers which dealt with the mechanics of solids had already been published, and another three volumes each of the same size, devoted to the mechanics of fluids, were in preparation.

The Kelvin Gold Medal is awarded triennially as a mark of distinction in engineering work or investigation of the kinds with which Lord Kelvin was especially identified.

Barton Bridge Accident

THE accident at Barton Bridge—a steel road bridge crossing the Manchester Ship Canal and forming part of the Stretford–Eccles motorway scheme—was reported quite fully in our issue of January 8 last, from which it may be recalled that four girders, together comprising half the width of the bridge and forming a cantilever and anchor arm, toppled sideways. Two men were killed, and the evidence and findings at their inquest, which concluded on Saturday, February 6, included a detailed appraisal of the failure.

An expert examination of the fallen girders was made by Professor Wilfred Merchant, D.Sc., M.I.Struct.E. (professor of structural engineering, Manchester College of Science and Technology). The professor pointed out that the four girders had been erected in their approximate positions using temporary trestle towers as additional supports between the two concrete piers. They were not straight, and not in their final lateral position, so the final transverse bracing could not be inserted. He said that the girders were each 18ft deep and had a flange width of 2ft. 3in. The horizontal force needed for overturning was 5 tons. One girder standing on its base by itself was, in his opinion, a dangerous structure. The four girders together did not prop each other, and would collapse in the manner of upright books knocked over on a shelf. The professor's conclusion was that the four girders represented a hazard which should not prudently have been taken. The stability of the girders, he then explained, had been further reduced by raising them on their jacks. Less restraint against rotation was given by jacks than by a solid base, and the lifting of girders which were not straight and level would cause overturning. There was no diagonal bracing between them and little horizontal bracing; the bolts and one horizontal brace put in on the morning of the accident had little effect on the overall stability.

There was no evidence, the professor said, that the collapse was more than a toppling over of the four girders during an operation done with inadequate bracing. There was a conflict of evidence about the handling of the jacks, but the method of erection of the girders should have been such that failure of the jacks should not have caused disaster. The two major contributing factors were the instability of the girders and the jacking operation.

The jury were advised by the coroner that there was no criminal negligence. It may be recalled that prior to the accident the main contractor (the main contractor for the bridge is G. Dew and Co., Ltd., and it is being built under the direction of the county surveyor and bridgemaster of Lancashire, Mr. James Drake, M.I.C.E.) had terminated the employment of Samuel Butler and Co., Ltd. as sub-contractor for supply and erection of the steelwork, due to labour troubles with the latter firm's employees. The coroner referred to these conditions—he doubted whether there had been effective control of the site labour in the three weeks before the accident—and to correspondence before the accident and said there was no doubt that the bracing was sadly deficient. When the new firm of steel erectors—the United Steel Structural Company—took over, a general foreman was in charge. There was no evidence, he said, that any technically qualified people carried out a detailed and full inspection, before work was restarted, under conditions in which the virtual order of the day was "to get on with it."

Following upon the coroner's later remarks, the jury returned a verdict of accidental death on the two men, and recommended "that a fully qualified technical and/or professional co-ordination officer should be appointed for such contracts by the main contractor; and legislation should be introduced to ensure the safety of all concerned with this type of work."

Trans-Pacific Telephone Cable

THE Pacific Cable Conference, held in Sydney in September-October last year on the initiative of the Australian Government, recommended that work should proceed on constructing a large-capacity telephone cable across the Pacific from Vancouver to New Zealand and Australia. Having considered the conference's report, the U.K. Government has informed the other participating governments (Canada, Australia and New Zealand) that it accepts the recommendations and is ready to go ahead with construction of the cable. The other three governments have also accepted the report. Cable and Wireless, Ltd., will act for the United Kingdom Government in the construction, maintenance and financing of the cable. The total estimated cost is £26,300,000, of which the U.K. share is £8,300,000.

The new cable, which it is hoped to complete in 1964, will form a further link in the "round-the-world" telephone cable system proposed by the Commonwealth Telecommunications Conference which met in London in 1958. The first part of the system will be the new cable to Canada (generally known as C.A.N.T.A.T.) which is due for completion next year. C.A.N.T.A.T. will be linked to the trans-Pacific cable by lines across Canada, the complete system providing first-class telephone and telegraph communications halfway round the the world, a route distance of about 14,000 miles. The trans-Pacific section will be over 8000 nautical miles long and will include more than 300 undersea amplifiers. In places, cable and amplifiers will be laid at depths of almost 4 miles.

Management of the project will be under the control of a four-man management committee (one representative from each country). The scheme will be engineered by a joint development group based on the British-Canadian group which is engineering C.A.N.T.A.T. This group will be led by Mr. R. J. Halsey, Director of Research of the United Kingdom Post Office and a Director of Cable and Wireless, Ltd. The installation will comprise the lightweight cable and rigid repeaters developed in the United Kingdom and being used in C.A.N.T.A.T.; it will have capacity for at least eighty simultaneous conversations. Any one of the telephone circuits can be used to provide twenty-four telegraph channels.

Computer Exhibition and Symposium

A SECOND Electronic Computer Exhibition will be held next year, from October 4 to October 12, in the National Hall, Olympia, London, and a second Business Computer Symposium will take place concurrently. This announcement is made by the joint committee of the Electronic Engineering Association (E.E.A.) and the Office Appliance and Business Equipment Trades Association (O.A.B.E.T.A.), which organised the first exhibition of this kind at the end of 1958. It is estimated that since that time the value of export sales of British computers has been £1,750,000. Mr. Vernon M. Roberts, chairman of the joint committee, has said that the 1958 exhibition was intended to be a "once only," but the reaction from users and potential users, particularly abroad, had been very much in favour of another one within two or three years. Their latest encouragement was that a mission from West Germany had said that British computers were competitive on the German market, both as regards quality and price, and they felt this might well be so in other markets.

French Nuclear Bomb Test

IT is reported that the first French test explosion of a nuclear device took place at 7 a.m. on February 13, at Reggane, an oasis in the Sahara, about 950 miles south of Oran. The device was mounted on top of a 300ft open-lattice metal tower and firing was initiated by electronic remote control. Later it was stated that the first tests made after the explosion gave no indication of radioactive fall-out over inhabited regions. One of the objects of the explosion was to test its effects on French war material, including army transport vehicles, tanks, aircraft and aircraft equipment, packaged foods and medical supplies, placed at selected distances from the tower.

Radio Telephones on Trains

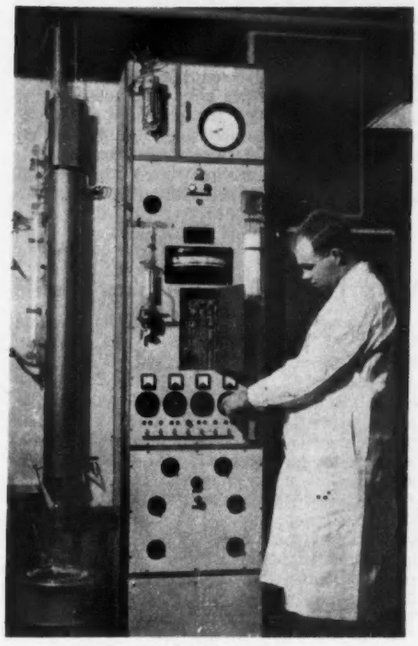
BRITISH RAILWAYS, London Midland Region, has co-operated with the Post Office and Pye Telecommunications, Ltd., in carrying out a series of trials with mobile v.h.f. radio telephone equipment fitted in a railway brake van. Test journeys were made last week between Crewe and Lancaster, Crewe and Liverpool, Crewe and Manchester, and Crewe, Chester and Birkenhead. In this area the G.P.O. has established two radio telephony stations for its public radio telephone service for car and road vehicle owners (see our November 6, 1959, issue). The railway trials have been undertaken for technical experimental purposes only.

Industrial Electronics Conference

THE Electronic Forum for Industry, consisting of associations in Great Britain aiming at making better known the developments and applications of electronics in industry, is to hold a three-day conference at Olympia, London, on May 24, 25 and 26 next, when the Instruments, Electronics and Automation Exhibition is in progress. Details of the conference will be announced later, but broadly the three sessions will cover practical experience of data processing, factory applications (including machine tool control) and instrumentation. This will be the forum's first full-scale conference, but it is already pursuing its objectives by publication of a bulletin in which papers read at an open meeting and other articles have been published.

Production Distillation Simulator

AT the research centre of the British Petroleum Company, Ltd., at Sunbury-on-Thames, there has been developed the B.P. Free Standing 14-Plate Atmospheric and Vacuum Distillation Apparatus which is manufactured by Winston Electronics, Ltd., Shepperton, Middlesex. The unit which was developed originally for the distillation assay of crude oil, has also proved to be suitable for a wide range of laboratory



B.P. free-standing fourteen-plate atmospheric and vacuum distillation apparatus

distillation work in organic chemistry, particularly in the field of petroleum and solvents. This apparatus has a large capacity, high throughput, together with ease of control, and is suitable for operation at both atmospheric and reduced pressures. In addition, light gaseous components can be handled in the liquid phase by circulation of a refrigerant in the condenser and receiver system and provision is made for metering incondensable gases.

The normal charge is 4 litres, which enables a sufficient quantity of each fraction to be obtained for analysis and refining purposes. Our illustration shows the apparatus which has a standard column having an internal diameter of 36mm, a length of 1370mm and a packed length of 1220mm, the packing being stainless steel boot eyelets and giving a plate efficiency of 14. Alternative packings are available and the column operates under adiabatic conditions. In the assay of crude oil complete data can be obtained by means of a pilot plant. However, for a more general assay involving a true boiling point distillation and the preparation of yield data and curves of the significant properties of distillate fractions, the B.P. 14-plate distillation equipment gives a sufficient degree of fractionation to enable these data to be obtained.

Narrow boiling fractions can be analysed separately or blended in aliquot proportions to produce a number of refinery specification products for analysis. The residue from the distillation can be utilised to prepare a series of residues of differing cut point by back blending with the distillate fractions.

A typical range of cuts prepared for crude oil assay is as follows :

	Temperature, deg. Cent.	
Atmospheric pressure	15–95	Light gasoline
	95–140	Gasoline
	149–175	Naphtha
100mm mercury	175–232	Kerosene
2mm mercury at 250 deg. Cent.	232–288	Light gas oil
	288–343	Medium gas oil
	343–371	Heavy gas oil
	>371	Residue

[Reply Card No. E3071]

Battery-Operated Depthmeter

FOUR hearing aid cells provide the power for the electronic depthmeter illustrated, in which transistor techniques have enabled all circuits, batteries and a direct-reading meter to be incorporated in a single unit measuring 8¼in by 4⅞in by 3½in, and weighing 4½ lb. The instrument, known as the "Hecta" depthmeter, is manufactured by Brookes and Gatehouse, Ltd., 5, Captains' Row, Lymington, Hants, and is particularly suitable by reason of its dimensions, weight and low consumption (0·1W) for yachts and fishing boats, or may be sent off for reconnaissance in a dinghy while the parent vessel lies to in deep water.

A single transducer, consisting of a barium-titanate disc, is used for transmission and reception of pulses as in full-scale ultrasonic echo-sounding practice. This is contained in the small cylinder of "Fibreglass" seen in the illustration. Pulses are transmitted at a constant repetition rate. The leading edge of every pulse drives a bistable stage into one of its two states, and the leading edge of every echo restores it to its original state. This action is caused to make and break a circuit by which current flows from the battery at a constant rate into a reservoir capacitor. Consequently the charge received by the capacitor on each pulse cycle is proportional to the depth of water. The capacitor discharges through the meter and so drives a steady current through it which under equilibrium conditions is also proportional to depth. Readings are given either in feet or fathoms, the latter being achieved by switching resistance in series with the electronic relay circuit so that the charge injected per cycle is reduced six-fold. The simple pointer and scale indication given by the meter can be read in bright sunlight easily and precisely. Provision is made for connecting an external meter. This may be a recording instrument, and we understand that an Elliott clockwork-driven portable recorder has been used successfully in conjunction with the "Hecta" depthmeter in survey work. Normal accuracy is ±5 per cent of the depth, or 6in, whichever is the greater, but instruments for surveying can be supplied to special order having a guaranteed accuracy of ±3 per cent.

[Reply Card No. E3072]

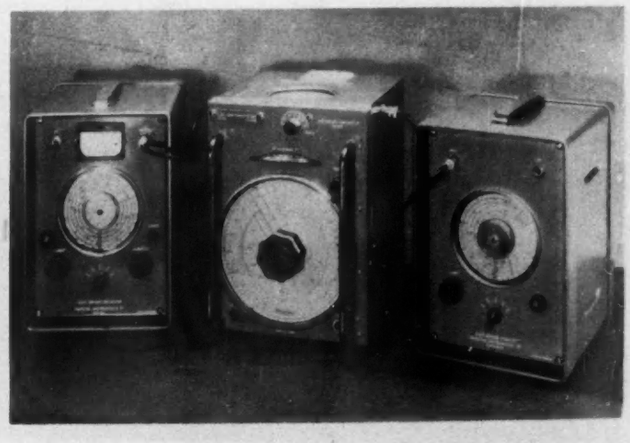
V.H.F. Admittance Bridge

ADMITTANCE measurements on the v.h.f. frequencies from 30 to 300 Mc/s are liable to disturbance by stray admittances of magnitudes comparable with the intended circuit values. The bridge instrument illustrated, made by Marconi Instruments, Ltd., St. Albans, Herts, uses a thermistor bead arrangement, based on principles originated by the B.B.C. Research Department, for reducing residual strays to negligible proportions. The bead is connected in one arm of a capacitor ratio-arm bridge as the conductance transfer standard. It is maintained at the value of conductance required for balancing the bridge by making it part of what is virtually an amplitude-stabilised Wien bridge oscillator, with one arm of the stabilising network made into a rheostat (the conductance balance control), thus allowing the power through the thermistor to be varied by variation of the feed-back factor. The amplifier, in maintaining the loop gain at unity, automatically supplies the thermistor with the correct amount of power for its conductance to correspond with the setting of the rheostat.

The instrument (TF978) is stated to be particularly suitable for measurements on unbalanced aerial systems, coaxial transmission lines and distributed components in general. It is arranged for use with an external oscillator and detector, and is illustrated in conjunction with the TF1274 oscillator and TF1275 detector which have been designed specially for the purpose.

This direct-reading admittance bridge measures conductance over the range 0 to 50 millimhos, and capacitance from −40 to +40μμF (negative capacitance is converted to inductance by use of formula). Balance is indicated on two wide-scale dials ; zero balance controls are incorporated for initial setting up. The special form of conductance standard has enabled all r.f. components of the bridge, apart from the trimming capacitor and the input and output transformers, to be contained in a space of ⅛in by ⅛in by 1/16in.

[Reply Card No. E3073]



(Left) Portable electronic depthmeter and underwater transducer. (Right) Admittance bridge (centre) for 30 to 300 Mc/s set up for use with oscillator (right) and super-regenerative detector (left) with visual balance indicator

SHORTER REPORTS *(Continued)*

Formaldehyde Plant at Oldbury

A PLANT to manufacture formaldehyde, which is a basic raw material in the production of aminoplastic moulding powders and resins, has been built at Oldbury for B.I.P. Chemicals, Ltd. The site chosen is centrally placed so that the plant can serve three of the company's chemicals factories. The new plant, of which we reproduce a general view, forms part of an expansion programme, part of which envisaged the company providing its own supply of formaldehyde. Leonard Smith (Engineers), Ltd., was responsible for manufacture and erection, and Mr. K. Nickels for design, of the plant which includes storage for methanol and formaldehyde, a cooling tower, refrigeration equipment, and an electric sub-station and which has a daily capacity of 75 tons of 37 per cent formaldehyde.

Since the site selected is not near to an oil refinery the process adopted uses methanol as its raw material with dehydrogenation over a silver catalyst. To prevent poisoning of the catalyst the design provided for ensuring the purity of the raw materials, namely methanol, steam and air. For storing the methanol there are three steel tanks having an overall capacity of 1000 tons and being built within bunds. From storage the raw material is pumped to a steam-heated vaporiser, both the level and temperature being automatically controlled, the latter figure being the determining factor in the methanol/air ratio. This ratio in turn determines the temperature of the catalyst bed. Before entering the process the air is filtered and passes through an electrostatic precipitator and is then blown through a methanol circulated column and then, clean and dry, the air is bubbled through the methanol in the vaporiser at a rate automatically controlled by the production tonnage required. The mixture of air and methanol vapour is superheated and filtered steam added, and then the mixture of the three after passing through a flame trap enters the converter where it passes downward through a shallow catalyst bed, of silver crystals on copper gauze, the temperature of which is approximately 600-650 deg. Cent. From the converter the gas enters a cooler which is fed with condensate, which in cooling the gas generates process steam at 30 lb per square inch. The cooled gas passes through a condenser the cooling water of which is circulated through a heat exchanger in the vaporiser. Both uncondensed gas and condensed gas are led to a scrubber having trays fitted with water cooling coils. Gases pass to atmosphere through a packed scrubber, while the product is pumped to scale tanks and blended before being forwarded to storage from which it is supplied through stainless steel pipes to the moulding powder and resin factories. Two acid-resisting brick-lined tanks of reinforced concrete provide storage for 400 tons of formaldehyde.

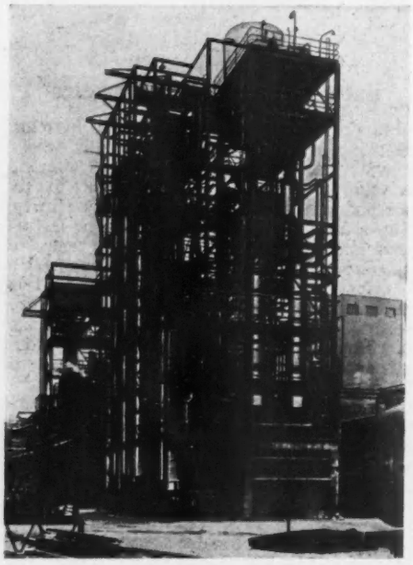
Owing to the high degree of fire and explosion risk stringent safety precautions have been incorporated within the plant area. Provision has been made for flooding the bunds surrounding the methanol tanks and for injecting foam into the tanks while the electrical equipment fitted is flameproof and the blower room, control room and laboratory are pressurised.

[Reply Card No. E3081]

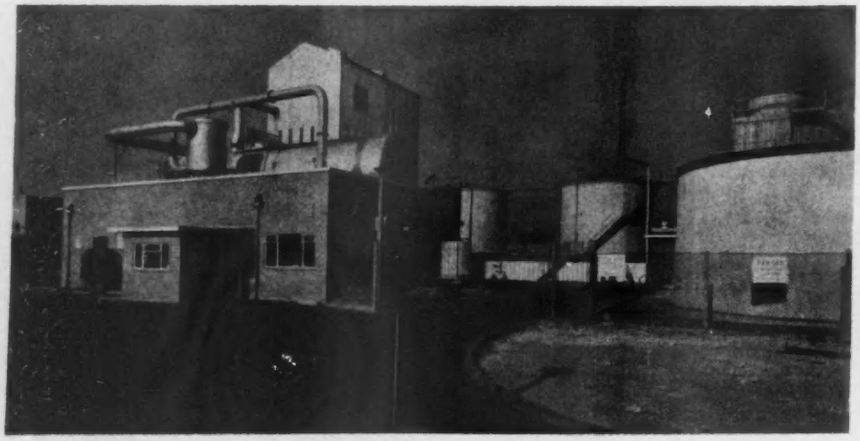
Continuous Benzole Fractionating Unit

WE have been informed that a new continuous benzole refining plant, which has been designed and constructed by the Chemical Engineering Division of The A.P.V. Company, Ltd., is now on stream at the Scunthorpe Coke Oven and Chemical Plant of the Appleby-Frodingham Steel Company, Ltd. The plant, illustrated herewith, has a designed output of 5,500,000 gallons per year and is the first to produce nitration grade boiling range benzole and toluole, 2 deg. xylole and 160 deg./190 deg. naphtha, continuously from crude coke oven benzole. Also noteworthy in the design is the advance in the field of benzole refining made by the operation of five continuous fractionating columns in series. The refinery incorporates an A.P.V. continuous defronting unit which is capable of producing defronted benzole, containing as little as one part per million of carbon disulphide, with a very low loss of benzene in the overhead fronts. It is claimed that in a test run, it was established that, at a throughput rate of 650 gallons per hour of crude benzole, the refinery produced the products previously mentioned, at a steam consumption of less than 11·8 lb per gallon of crude, and that during subsequent operations this steam consumption rate has been considerably reduced.

[Reply Card No. E3082]



General view of benzole refinery



Formaldehyde plant at Oldbury

Wind Tunnel Tests on Ship Models

A PAPER entitled "Wind Tunnel Tests on Models of Merchant Ships" was read by K. D. A. Shearer, D.R.T.C., and W. M. Lynn, on February 12, before the North East Coast Institution of Engineers and Shipbuilders. The paper states that to provide data on the wind resistance of certain modern ship designs, wind tunnel tests have been carried out on 1/60th scale models of a tanker and two cargo ships and on 1/64th scale and 1/128th scale models of a passenger liner. The tanker and cargo vessel models were tested in three conditions of loading, and the magnitude and direction of the resultant force and moment about amidships are given for a free stream tunnel velocity of 100ft per second over a range of relative wind from 0 to 180 deg. off the bow. These models were tested in a wind gradient.

The larger liner model was tested in a wind gradient condition and the smaller model in both the wind gradient and uniform wind conditions, and the magnitude and direction of the resultant force and moment about amidships were measured. Two 1/128th scale models were used for measuring the wind resistance in the uniform wind condition, one of them acting as a reflection model. With the exception of the reflection model, all tests were carried out with the models in the boundary layer close to the tunnel roof. For the 1/64th and 1/60th scale models the resultant velocity gradient was considered to be reasonably close to the gradient obtained under natural conditions above the surface of the sea.

The model results are shown in a non-dimensional form, using an ahead resistance coefficient K, and are compared with some published data. Certain possible inaccuracies in applying the model results to the ship conditions are discussed. There are two appendices, of which the first considers the factors affecting the natural wind velocity gradient above the surface of the sea and the second gives results obtained from wind speed measurements made at various points on the models. Diagrams indicate possible serious errors in speed measurements due to poor siting of an anemometer.

Demonstration of Flow Transition

THE classic manner of distinguishing laminar from turbulent flow is by visualisation. The Reynolds experiment, demonstrating the criterion for transition, is therefore well adapted to be constructed on "Quickfit" Visible Flow principles and such an apparatus has now been developed. It consists of a vertical glass tube, surrounded by a water jacket to suppress convection effects, supplied through a "Rotameter" which is calibrated up to 200 gallons per hour. Dye is injected into the flow through two jets near to the centre and the wall of the tube for flow visualisation. Details are available from Q.V.F., Ltd., Duke Street, Fenton, Stoke-on-Trent, Staffs.

[Reply Card No. E3084]

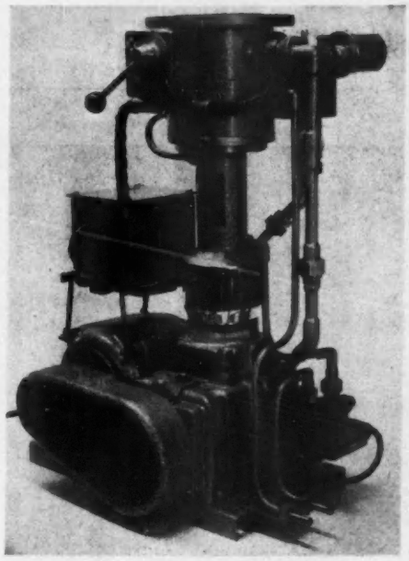
Special Automotive Lubricants

In the automotive industry streamlining has tended to reduce the height of vehicles, and this trend has lowered the centre of gravity and enhanced road stability at high speeds. These changes in styling are responsible for engineering modifications that require the attention of engineers, metallurgists, chemists and physicists before they can be incorporated in new models. Research teams have to study the behaviour of the engine components that have had to be redesigned and an example is the hypoid bevel gears presently used in the back axle of cars and trucks. In this design, the teeth of the gears contact at an offset angle resulting in the teeth being subjected to very high loadings and a considerable degree of tooth sliding which can cause excessive wear. These problems are aggravated as engine power and road speed increase.

Protection of these gears is accomplished by the gear lubricant preventing the gear surfaces coming together and welding under the heat developed by the combination of high sliding speed and the shocks resulting from rapid acceleration and quick stops. Certain axle designs are more severe in their lubrication requirements than others, particularly during the early life of gears before they are run-in. At the Thornton Research Centre of "Shell" Research, Ltd., in Cheshire, continuous studies are made of the hypoid gears and special tests have been developed to evaluate lubricant performance. In this way lubricants capable of meeting the latest demands of the motor industry are developed.

In shock tests a fully laden car is driven at high speed, the engine disengaged by the clutch and switched off. Then the clutch is abruptly re-engaged against the static engine, thus imposing a heavy shock load against the gears, and this procedure is repeated several times in each gear. To assess the performance of oils under high load and low speed conditions, such as are experienced when towing caravans, a hypoid gear rig, shown in our illustration, is used and simulates conditions representing a non-stop steady drive, fully laden up a severe incline for some 300 miles. A chassis dynamometer permits stimulation of high speed operation to evaluate gear oil performance during the running-in of new gears. Tests are also carried out on the track at the Motor Industries Research Proving Ground, Nuneaton, and fully-laden commercial vehicles tow the M.I.R.A. road dynamometer round the circuit, simulating a steady drive up severe inclines.

[Reply Card No. E3091]



Automatic high-vacuum pumping equipment

Vacuum Pumping Set

An automatic high-vacuum pumping equipment with single lever control made by N.G.N. Electrical, Ltd., Avenue Parade, Accrington, designed to give an ultimate of better than 5×10^{-6} mm Hg, is available in two sizes with pumping speeds of 23 or 100 litres per second. The equipments combine fractionating diffusion pumps and gas ballasted backing pumps to allow the evacuation of chambers containing condensable vapours.

These equipments, one of which is illustrated, are built up from the maker's standard components and they are fully protected against power failure or accidental stoppage.

In the event of accidental stoppage or power failure, a unit is automatically isolated; thus damage cannot be caused to the plant or apparatus in the vessel being evacuated, i.e. if the plant is positioned on fine pump and inadvertently the power supply is cut off, the backing line is closed by a magnetic isolation valve and air automatically is admitted through a valve. The operation of these two valves is delayed by a two-second time dwell which prevents oil being sucked out of the rotary pump into the backing or roughing line. When the electrical supply is reconnected, the air admittance valve closes and a time lag occurs, allowing the backing or roughing line to be pumped down before the isolation valve opens. Consequently the vacuum in the vessel is maintained and hot oil in the diffusion pump does not come into contact with atmosphere. If the cooling water to the diffusion pump is inadvertently cut off, a red light indication is given to the operator and the heater to the diffusion pump is automatically shut down.

The operating handle of the set has four positions—rough pump, fine pump, isolation and air admittance. When the unit is set on rough pump, the vessel being evacuated is pumped down to approximately 350 microns before fine pump selection occurs, which brings the diffusion pump into circuit; at this setting the rotary pump acts as the backing pump. The isolation position of the lever isolates both pumps from the vessel and on air admittance a magnetic valve is actuated, admitting air to the evacuated vessel.

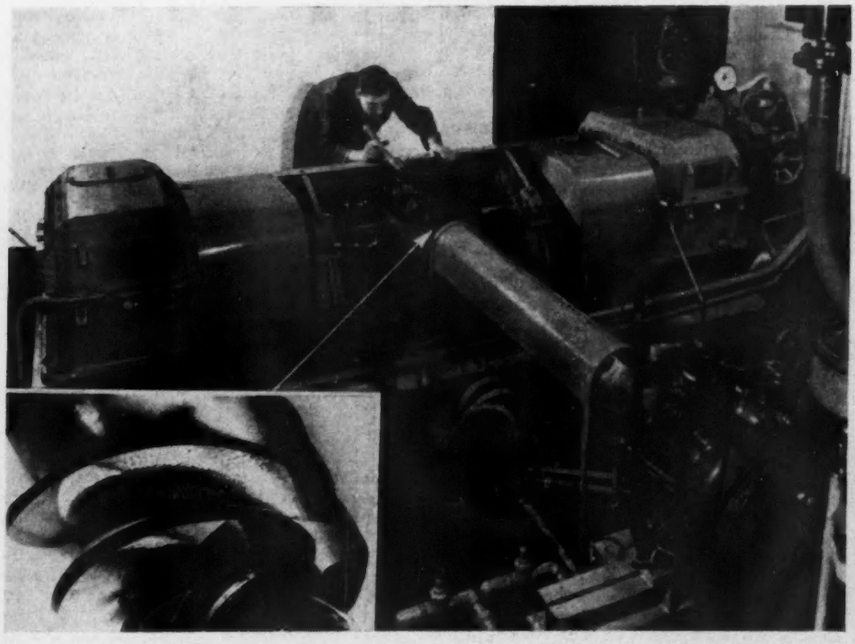
[Reply Card No. E3092]

35 B.H.P. Tractor

Towards the end of last year, the Tractor Division of The David Brown Corporation, Huddersfield, introduced the 950 "Implematic" tractor. It is a 42·5 b.h.p. machine, the "Implematic," as described in our issue of December 11, 1959, referring to an all-purpose hydraulic system designed to overcome the problem of incompatibility between automatic draught control and depth wheel control with mounted implements.

The David Brown Corporation is now putting into production a smaller version of this tractor. It is designated the 850 "Implematic" and is powered by a 35 b.h.p. four-cylinder direct injection diesel engine. The tractor is available in both standard and "Livedrive" forms, the latter having "live" power take-off and hydraulics operated by a two-stage clutch pedal. The standard equipment of the 850 "Implematic" includes a foot-pedal operated differential lock to give additional protection against wheel spin, the David Brown traction control unit, and a hand parking brake; provision is made for front and rear wheel adjustment from 52in to 76in in 4in steps. The calculated drawbar pull of the tractor is 5000 lb and there are six forward road speeds between 2·1 and 14·2 m.p.h. at the maximum engine speed of 2000 r.p.m. and low and high reverse speeds. Petrol or kerosene engines can be installed, if required, and the 850 tractor is also offered, without hydraulics and power take-off, as a basic machine for haulage work.

[Reply Card No. E3093]



Hypoid gear rig at Thornton Research Centre with inset showing "rippling"

Radio-Controlled Tugs

The Thames Steam Tug and Lighterage Company, Ltd., has found that by using two-way short wave radio to control its tugs and launches, considerable savings in time and money have been made. The company has fourteen tugs and launches, ranging from 80 h.p. to 400 h.p., and all but the smallest of these are now fitted with this equipment. From a broadcasting station at its offices, the boats, which operate from as far up stream as Brentford down to Tilbury, Shellhaven and Thameshaven, are given up-to-the-minute instructions and are themselves able to report back. The instructions are given by an employee who has a wide experience both of the river's tides and the work of the company, and should it be necessary to give new orders when a boat is on the river, it is not now necessary to wait until the boat returns to its moorings. Additionally, if a boat has been sent to pick up barges, which prove to be missing, the captain is able to receive new orders without having to dock and find a riverside telephone; similarly, breakdowns can be reported immediately.

The boats have Pye radio equipment, including a loudspeaker and telephone-speaking apparatus, mounted on the bridge so that the captain need not leave the wheel. On the smaller launches the radios are operated from engine starter batteries; however, the larger tugs, of up to 400 h.p., have two sets of Exide batteries, one set being in use while the other is on charge.

[Reply Card No. E3094]

SHORTER REPORTS *(Continued)*

Water Cooling Towers

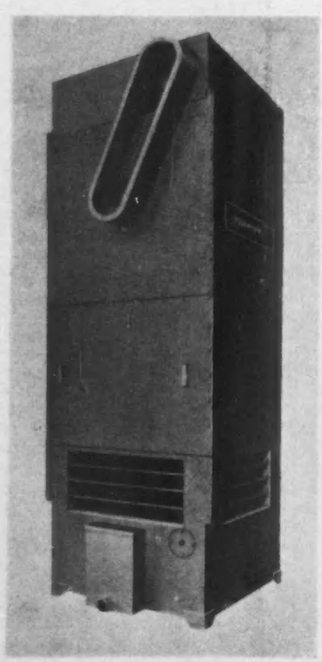
A RECENT addition to the water cooling towers in the " Aquamiser " range made by the Midland Heating and Ventilation Company, Ltd., Bedford Road, Birmingham, 11, is a design with packing sections of stainless steel expanded mesh. One of these new towers is illustrated below and they are made in a number of standard capacities. Typical water temperatures and flow rates of one of the largest units are given in the table below, with corresponding figures for the flow rates of the smallest size of tower in brackets.

Water flow, g.p.h.	Temperature into cooler	Temperature out of cooler	Ambient wet bulb
16,200 (1200)	130 deg. Fah.	90 deg. Fah.	65 deg. Fah.
15,000 (1080)	85 deg. Fah.	75 deg. Fah.	65 deg. Fah.
12,300 (930)	95 deg. Fah.	75 deg. Fah.	60 deg. Fah.
9,720 (720)	180 deg. Fah.	95 deg. Fah.	65 deg. Fah.

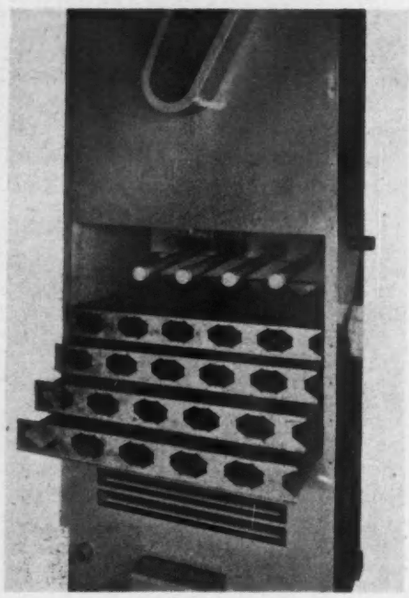
The largest capacity tower has cross sectional area of 54 square feet and the smallest 4 square feet, the respective overall heights being 15ft 8in and 10ft 2in.

Each tower has a rigid welded steel plate casing which is treated with anti-rusting solution and finished with acid-resisting paint. One of the maker's " Gyra-Flo " fans installed at the top of the tower draws air in through the louvred section and expels it through an opening in the top cover. The body of the tower contains a pack of six superimposed spreader units, as shown in our second illustration, each unit being fabricated from $\frac{1}{8}$in mesh 28 gauge expanded stainless steel formed into a honeycomb section. This use of stainless steel enables the spreader pack to withstand corrosion and algæ attack, whilst the problem of leaching away and causing blockages in the water ways does not arise.

The hot water to be cooled is delivered into a tank at the rear of the tower, whence it passes through tubes fitted with non-clogging nozzles extending through the width of the top deck of the spreader pack. The mesh in the spreader pack is so designed that it imparts a self-spreading effect to the water and tends to correct any variations in distribution from the nozzles. The counter-current of cooling air and the method by which the water is both " filmed " on the pack and induced as a spray ensures a large cooling area under working conditions.



Water cooling tower fitted with expanded stainless steel spreader pack



Arrangement of spreader pack units in cooling tower with top of pack removed to show spray tubes

The cooled water flows down into a tank formed in the base of the tower and the draw-off box of this tank is fitted with removable strainer plates. The water level in this tank is regulated by a ball cock.

[Reply Card No. E3101]

Crankshaft Failures

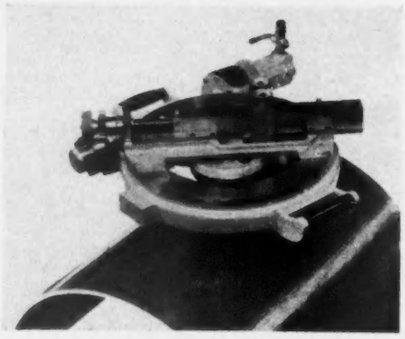
ON Tuesday, February 9, a paper with the title " Some Crankshaft Failures : Investigations, Causes and Remedies," was presented by R. Atkinson, B.Sc. (Eng.), and P. Jackson, M.Sc. (Eng.), before the Institute of Marine Engineers in London. The paper, of which we append a brief summary, recalls that about six years ago there were a number of failures of the Doxford 750mm engine crankshafts, and gives an account of these failures, together with the circumstances attending the investigations and also an outline of the remedies applied.

Various failures of the six cylinder, 750mm engine crankshafts were investigated and, as a result, certain main contributory factors emerged which required consideration, namely, the forgings, misalignment, recessed fillets, and influence of flexible couplings. Metallurgical examinations were carried out into the properties of the forgings and the method of forging was amended to ensure that the underside of the fillet was of sound material. In addition to the investigations into dynamic conditions and torsional vibrations, a check was made on the effect of misalignment. Hog and sag deflections were recorded, together with associated stress, and the figures indicated that misalignment considerably influenced stresses set up in crankshafts. Since all cracks were initiated in the recessed fillets, stress distribution in the side crank webs was examined and a pattern established and as a result the recessed fillet design was abandoned. The symmetrical position of the cracks relative to the flexible coupling pointed to this item having a detrimental effect and calculations showed that bending stresses in the crankshaft were considerably higher with a flexible coupling than with a rigid coupling. As a consequence, crankshafts were constructed with rigid couplings, a single flange design being eventually adopted. The adoption of these remedies eliminated the trouble. However, at a later date, there were two further breakages, but examination showed that the steel used and the method of manufacture were not satisfactory and that the failures did not invalidate the remedies previously adopted.

Portable Flange Facing and Turning Machines

A NEW model of the portable flange facing machine introduced some years ago by David Reekie and Sons, Ltd., 93, Hope Street, Glasgow, C.2, and described in some detail in our issue of March 25, 1955, is fitted with a universal tool holder by which the outside diameters of flanges can be turned to a depth of 3in. These electric or pneumatic motor-driven machines are suitable for turning the faces of flanges from 11½in bore to 28in outside diameter, and for recessing flanges from 13in to 24in diameter. A further development of this design of machine is the model " E " shown in our illustration, and which, in this case, is driven by an air motor.

The machine is fitted over the flange to be turned or faced and locked on the tube below the flange by centralising screws. As its ring-mounted tool slide is rotated by wormwheel from the air motor the tool is fed across the flange face at up to 0·02in per revolution by a star wheel at the end of the leadscrew contacting a trip. Flanges from 1in bore to 10in outside diameter can be faced or recessed to a depth of 1in, and their outside diameters turned to a depth of 1in with the machine. The machine can be located and locked on flanged tubes from 2in to 5½in outside diameter and requires a minimum length of 4in of tube for setting purposes. It can also be used to prepare tube ends for welding purposes on site by turning the outside diameter and generating a single bevel and root face.



Portable air-motor-driven machine for facing flanges from 11½in bore to 28in outside diameter

Another recently introduced portable air-driven machine of this firm profiles the ends of tubes for welding purposes. It can be used with tubes from 1½in bore to 4½in outside diameter and turns single bevels and root faces up to 45 deg. for welding purposes.

[Reply Card No. E3103]

Adjustable Damper

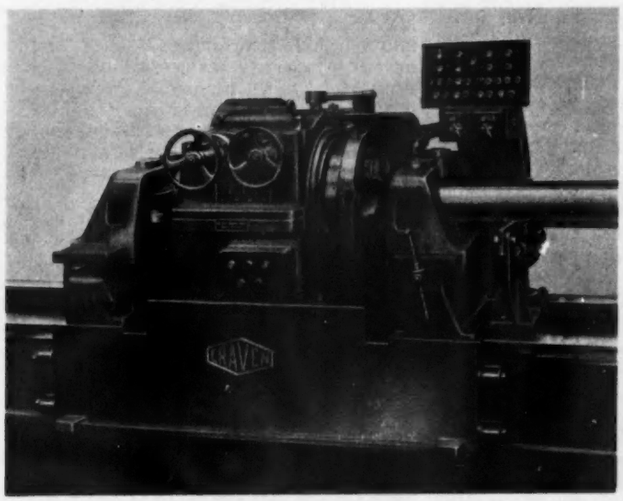
ADJUSTABLE hydraulic dampers are now available from Spax, Ltd., 61, Fortress Road, London, N.W.5, in a configuration having the shaft extending both sides of the body to pick up two ends of a suspension wishbone, as on Austin and M.G. cars. These Type 100 units are similar in principle to the Type 89 described and illustrated on page 229, February 6, 1959, but adjustment of the rebound valve is effected by a knob knurled for finger grip.

[Reply Card No. E3104]

Bar Skimming Machine

A LARGE bar skimming machine recently built by Craven Brothers (Manchester), Ltd., Reddish, Stockport, is designed to deal with mild steel or high-tensile steel bars from 3½in to 8½in diameter on a semi-automatic cycle and at high speeds. This machine is arranged for a continuous loading and cutting sequence and has a centralised electrical control of its hydraulically operated bar manipulation motions. As can be seen in one of our illustrations, the machine has a central headstock on each side of which there is a bar-feed saddle which traverses along a fabricated steel bed fitted with renewable cast iron wearing plates.

Two interchangeable rotating multi-tool heads are provided for fitting on the hollow spindled headstock, one head with four tools being suitable for skimming bars from 3½in to 6in diameter, and the other with six tools for bars from 5½in to 8½in diameter. The spindle is driven by a 70 h.p. constant speed motor through vee belts and change gears giving speeds of 31, 42, 55 and 75 r.p.m. All parts of the heads and tool holders exposed to wear from cuttings during machining are hard faced with a protective layer of "Stellite" metal. During machining the bars are supported on each side of the headstock by vee-roller guides which are adjustable in accordance with bar diameter and spring-loaded to provide for irregularities in a bar. Two vee head screw jacks can be adjusted along the bed if additional bar support is required.



Central headstock of skimming machine

The saddles are each mounted on hardened steel runner wheels to give ease of traverse along the bed, and two powerful self-centring vice jaws on each saddle are actuated by hydraulic cylinders. These jaws are so arranged that the bars can be rolled into and out of position from the front of the machine, cylindrical rollers being provided on the saddles to support the bars before they are gripped by the jaws and after they are released. A hydraulic supply unit, complete with its reservoir, is built into each saddle for operating the vice jaws.

Each saddle has a longitudinal traverse of 11ft and is actuated by a hydraulic piston and cylinder giving bar feed rates from 6in to 63in per minute and quick traverse rates from 7ft to 20ft per minute. Each of these hydraulic cylinders is supplied by an individual pumping set and the circuit is arranged to give hydraulic cushioning of the pistons at the ends of their strokes.

In the operating cycle of the machine a bar is rolled from a stack into position on the right-hand saddle, where it is gripped between the jaws. On feed traverse to the saddle then being started, the bar is fed forwards through the headstock roller guides and the revolving cutter head. When a predetermined length of the front end of the bar has passed through the headstock and cleared the guides it is gripped by the jaws of the left-hand saddle, of which the feed traverse has already been started. As this left-hand saddle begins its feed traverse of the bar through the headstock, the jaws of the right-hand saddle are released and it is quick-traversed back to its starting point to receive a further bar. This next bar is fed into the cutter head immediately behind the previous one, to give continuity of the cutting operation and during its initial machining the left-hand saddle has released the turned bar and been traversed back at high speed to its start position.

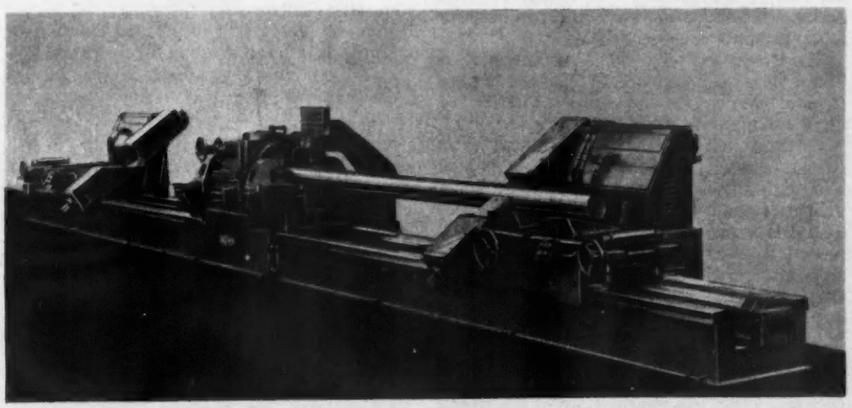
Any length of bar over the minimum of 11ft required to reach through the headstock can be handled on the machine, and the most convenient length of saddle traverse can be selected for any given length of bar. When dealing with very long bars, a quick traverse return of a saddle can be made and a second grip taken. The jaws are automatically released as the extremities of travel in either direction are approached, and the hydraulic clamping systems are automatically unloaded when the clamps are inoperative, thus conserving power and avoiding unnecessary heating-up of the oil.

All four hydraulic supply units are of the motor-driven, dual pump design, one pump being of high pressure, low volume, delivery, and the other of low pressure, high volume, delivery.

The high pressure pump is used for feed traverse and the low pressure for quick traverse in the case of the saddle units, and for pressure grip and fast approach respectively in the case of the jaws.

All of the operational hydraulic valves are solenoid operated by push-button switches. A central control station, conveniently situated adjacent to the cutting region, contains separate sets of buttons for the complete control of each saddle, its gripping jaws and hydraulic systems. Additional panels on each saddle duplicate its main control buttons, while a separate push-button panel on the headstock controls the main spindle driving motor.

[Reply Card No. E3111]

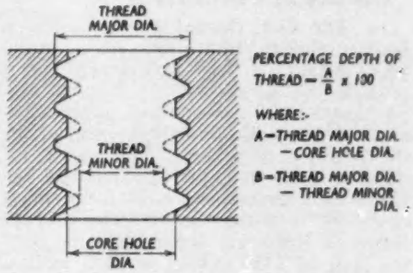


Hydraulically operated skimming machine for bars from 3½in to 8½in diameter

Research Report on Tapping

THE Production Engineering Research Association has just issued the first part of a report on an investigation into tapping, dealing with the relationship between core hole size and tapping torque and the effect of core hole size and depth or length of a tapped hole on the strength of a threaded assembly. The investigation was designed to ascertain to what extent core hole size can be increased without decreasing the strength of a tapped component when assembled with a bolt, stud or screw.

The report describes the method and equipment used in carrying out tests on a variety of materials with different sizes of taps, and its conclusions and recommendations are of particular interest. For the tap sizes and materials investigated it was found that, as might be well expected, tapping torque decreased as the core hole size increased. Due to swarf jamming variations in torque were greater at 90 per cent and 100 per cent depths of thread. Percentage depth of thread is defined as thread major diameter—core hole diameter/thread major diameter—thread minor diameter × 100, as shown in the diagram we reproduce. In connection with thread strength it was found that in a threaded assembly where tapped hole depth, or length, was equal to the thread major diameter, the strength of 65–70 tons per square inch high tensile steel bolts was less than the strength of the tapped threads at a thread depth of 60 per cent, and over for low carbon steel and stainless steel. Where the depth or length of a tapped hole was equal to or greater than the thread major diameter, the strength of the threaded assembly was not increased by providing a depth of thread greater than 60 per cent in aluminium alloy and 75 per cent in cast iron.


THREAD MAJOR DIA.
THREAD MINOR DIA.
CORE HOLE DIA.
PERCENTAGE DEPTH OF THREAD = A/B x 100
WHERE:-
A = THREAD MAJOR DIA. − CORE HOLE DIA.
B = THREAD MAJOR DIA. − THREAD MINOR DIA.

Definition of percentage depth of thread

The report states that the strength of B.S.W. threaded assemblies is lower than that of corresponding B.S.F. threaded assemblies where the depth of tapped hole is equal to the thread major diameter. The torque required to tap such B.S.W. threads is higher than that required to tap the B.S.F. threads.

As a result of the investigations it is recommended that when specifying tapped threads B.S.F. should be selected in preference to B.S.W. threads. When tapping steels and aluminium alloy the depth of thread should be 60 per cent, and for cast iron 75 per cent. With steels the depth or length of a tapped hole should be equal to the thread major diameter and with aluminium alloys or cast iron one and a half times the thread major diameter.

[Reply Card No. E3112]

INDUSTRIAL NEWS

Forty-Two-Hour Week

The Confederation of Shipbuilding and Engineering Unions has decided to accept the offer of the Engineering and Allied Employers' National Federation to reduce the standard working week from forty-four hours to forty-two, without loss of pay. Agreement on the matter was reached at a meeting, last week, of the executives of the unions which comprise the Confederation. The last reduction in the working week in the engineering industry, from forty-seven hours to forty-four, was made in 1947. Last autumn, the unions submitted claims for a " substantial wage increase " (subsequently naming £1 a week) and the introduction of a forty-hour week. Last November, the Engineering and Allied Employers National Federation gave a full reply to the unions, explaining that no increase in wages could be awarded but offering to reduce the working week to forty-two-and-a-half hours. That was not acceptable to the union confederation which, last month, re-submitted both claims. The employers' reply, given on January 26, reiterated the rejection of the wage increase and offered the forty-two-hour week. It is understood that the union confederation's acceptance of the offer was to be conveyed to the employers federation yesterday.

Gas Industry's Development

The Gas Council has published a booklet entitled *Gas Looks Ahead* which gives details of the development plans proposed by the gas industry over the next six years. The general lines of development, it is stated, have been accepted by the Minister of Power. To provide for them, the Gas Bill was introduced in the House of Commons last week ; the object of the Bill is to authorise an increase in the industry's borrowing powers from the existing limit of £450 million to £525 million. The booklet shows that in the seven-year period, April 1, 1959 to March 31, 1966, the gas industry's capital investment is forecast as £370 million. Against that, a figure of £256 million is set as depreciation and income derived from other internal sources, so that the new borrowing is put at £114 million or 32 per cent of the capital investment envisaged.

In the ten years since nationalisation, the demand for gas has risen by 12 per cent, and it is estimated that by 1966 there will be a further increase of 9 per cent, the largest proportion being in the development of industrial supplies. The gas industry takes the view that coal will be the nation's major source of fuel for many years to come. But good carbonisation coals, the gas industry's traditional raw material, have become scarcer and costlier and research has therefore been concentrated recently on processes for the complete gasification of poorer quality coals.

A works for the complete gasification of coal under pressure by the Lurgi process is at present being built by the Scottish Gas Board at Westfield, Fife (THE ENGINEER, October 30, 1959) and another Lurgi plant, at Coleshill, Birmingham, for the West Midlands Gas Board, has been approved by the Minister of Power. The Gas Council's research programme includes the construction for the North-Western Gas Board, at Partington, Manchester, of a large-scale pilot plant based on the hydrogenation process. This is intended to develop new techniques which can be applied as quickly as possible to the gasification of low grade coals, but, to get the speediest results, it will first be tested on a variety of oil feedstocks. Increases in the use of oil gas-making plant and of tail gases from oil refineries are envisaged and trials are continuing with the experimental imports of liquid natural gas.

The Gas Council says that if all these developments fulfil their promise, the future pattern of gas supply may be a few relatively large gas works, near coalfields or oil refineries, gasifying a range of small coals and all fractions of oil at high pressures. This gas would be fed into arterial mains—a national grid system—which could also take surplus gas from coke ovens, gas still made in some conventional gas works and gas produced from liquefied methane. This, inevitably, is a long-term project, but the Gas Council is already studying the technical and economic aspects of a national grid in relation to new methods of gas production and supply.

Iron and Steel

The demand for iron and steel continues to improve and, in the month of January, British steel output reached a new record. Steel production averaged 471,400 tons a week, which was about one-third higher than a year previously, and which represented an annual rate of 23,600,000 tons. It is expected that, for this year as a whole, steel production may amount to 24,000,000 tons, which will be 20 per cent above last year. Pig iron production in January also reached a record figure of 297,500 tons a week.

The Iron and Steel Board says that, of the anticipated increase in home steel demand this year, it is estimated that about half will come from increased consumption and half from a change from running-down to the building-up of producers' and consumers' stocks. Preliminary figures suggest that the general running-down in consumers' stocks which started in the second quarter of 1958 was halted during the final quarter of 1959. Stocks at the end of last December showed little change in total compared with those at the end of September ; stocks held by the nationalised industries were lower but stocks in the private sector were rising.

The Board has published some statistics of home deliveries of steel. These compare steel deliveries in the fourth quarter of 1957, the highest figures before the recession, with those in the fourth quarter of 1958 (which is taken as the low point of recession) and with the fourth quarter of 1959 when deliveries had almost entirely recovered. The industries primarily affected by the recession were railways, coal mining and shipbuilding, steel deliveries to which fell by one-third between the final quarters of 1957 and 1958. These industries have not shared in the subsequent recovery, steel deliveries to coal mining remaining virtually unchanged but those to railways and shipbuilding continuing to fall. In contrast, deliveries to the consumers goods industries fell by only about 15 per cent between the end of 1957 and the last quarter of 1958, since when they have risen to about 15 per cent above previous peak levels. The main swing was shown by building and constructional engineering, in which, by the fourth quarter of 1958, steel deliveries were one-third lower than a year earlier. By the end of last year deliveries to those industries had returned almost to " pre-recession " levels.

Industrial Trends

The Federation of British Industries has recently completed its seventh inquiry into industrial trends in this country. Information which has been provided by 724 firms relates to the position at the beginning of this month.

The F.B.I. says that an outstanding feature of this latest enquiry is the upward trend in anticipated capital investment over the next twelve months. Last October, for the first time since these inquiries were instituted, the increase in future investment in plant and machinery outweighed the decreases. This trend, the F.B.I. states, has continued more strongly, and the latest return shows a rise in plans for industrial building during the year ahead. The rising trend in capital investment intentions, it is added, is confirmed by the replies made to a question about orders received for items of capital equipment. Counting only those firms to which this question was relevant, the percentages are 48 per cent up, 40 per cent the same (as October) and 11 per cent down.

The report goes on to affirm that " optimism about the general business situation continues to be pronounced." The trends in output, the rate of new orders both for home and export, and the length of order books are rising a little more strongly than in October. But, it is asserted, the trend in export orders still lags behind home trade. Higher output, it is observed, has been achieved both by higher employment and more overtime, the emphasis being on the former. Of the total number of firms providing information, 53 per cent report that they are working to capacity, compared with 50 per cent in October. The inquiry has suggested that unit costs may be hardening, although 70 per cent of the firms which replied report no change in the general level of their selling prices. The general picture, the F.B.I. claims, is of continued expansion and of sustained optimism for the future. It adds " there is little sign that inflationary pressures have yet begun to operate, though the hardening labour position is a warning for the future."

Laid-Up Shipping

According to returns made by the Chamber of Shipping, the laid-up British shipping at the beginning of February amounted to forty-eight dry cargo ships of 303,352 tons gross, or 2 per cent, and sixty-seven oil tankers of 584,449 tons gross, or 9 per cent, making a total of 887,801 tons gross, equivalent to 4 per cent of the merchant fleet. Throughout the world, 2,749,608 tons gross of dry cargo ships and 3,163,938 tons gross of oil tankers were laid-up for lack of employment, making a total of 5,913,546 tons gross, or 6 per cent of the total tonnage, and included nearly 4,000,000 tons built prior to 1945.

PERSONAL AND BUSINESS

Appointments

MR. MAURICE BRENNAN, chief engineer of Folland Aircraft, Ltd., has been appointed a director.

MR. A. J. INGRAM has taken up an appointment on the outside sales advisory staff of Blackstone and Co., Ltd.

MR. R. S. ODD has been appointed joint managing director of Lansing Bagnall, Ltd., with effect from April 1.

MR. ERIC H. BAKER, M.I.Mech.E., has been appointed assistant chief mechanical and electrical engineer, London Midland Region, British Railways.

BRYMBO STEEL WORKS, Ltd., announces that Mr. A. F. Gadsby resigned his directorship on December 31, 1959. Mr. P. H. Meadows has been appointed a director.

MR. C. W. HAMILTON has been elected president and Mr. A. J. Harris, M.I.C.E., vice-president, of the Council of the Prestressed Concrete Development Group for 1960.

THE PLESSEY COMPANY, Ltd., announces that Brigadier J. D. Haigh, M.I.E.E., has been appointed divisional manager of its capacitors and resistors division, Swindon.

MR. JOHN F. PERRY has been appointed chairman of Fluidrive Engineering Company, Ltd., in succession to Mr. Harold Sinclair. Mr. Sinclair has also retired from the board of directors.

Mr. W. H. HAUGH has been appointed manager of the Glasgow branch office of Renold Chains, Ltd., in succession to Mr. S. H. Foster, who has taken up other duties at Renold House, Manchester.

F. PERKINS, Ltd., has announced that Mr. Kenneth Baird has been appointed manager and Mr. Keith Gerrard assistant manager, of the group's newly-constituted personnel and industrial relations division.

MR. R. N. MILLAR, a director of The General Electric Company, Ltd., has been appointed managing director of the company's engineering group which has its main works at Erith, Kent, and Witton, Birmingham.

THE OWEN ORGANISATION states that Mr. E. J. Boag has been appointed director and general manager of C. and L. Hill, Ltd. Mr. W. A. Bannister becomes sales director and Mr. L. E. Morris continues as works director.

KEITH BLACKMAN, Ltd., announces that Mr. H. W. Wright has been appointed head of the electrical department at the head office and works at Tottenham, following the death of Mr. J. Kenyon, chief electrical engineer, on January 28.

THE MINISTRY OF HOUSING AND LOCAL GOVERNMENT announces that General Sir Nevil Brownjohn has been appointed a member of Crawley New Town Development Corporation, with a view to his succeeding Sir Thomas Bennett as chairman when he retires in a few months' time.

MR. A. J. WILSON has joined the board of directors of Charlton Weddle and Co., Ltd. He will continue as managing director of Wilson, Taylor and Co., Ltd., 4, New London Street, London, E.C.3, and Charlton Weddle and Co., Ltd., will also establish its London office at this address.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., states that Mr. L. C. Richards, until recently chief engineer of its transformer division at Manchester, has become chief engineer to Heavy Electricals, Ltd., India. He has been seconded to this position from A.E.I. Overseas, Ltd., to which he has been transferred.

A.E.I. (RUGBY), Ltd., announces that Mr. Reginald Oulton, general manager, and Mr. Alfred Pourtales Castellain, chief engineer of A.E.I. Sound Equipment, Ltd., have been appointed executive directors of that company. Mr. Ernest Victor Bowers, formerly managing director of A.E.I. Sound Equipment, Ltd., has resigned from his executive duties to join A.E.I. Lamp and Lighting Company, Ltd., but retains his directorship.

MR. LESLIE H. DAVIS, A.M.I.Mech.E., lubricants supervisor and assistant to Mr. A. E. McAulay, lubricants manager, Scottish Oils and Shell-Mex, Ltd., has been appointed lubricants manager, southern division, Shell-Mex and B.P., Ltd., Southampton. Mr. W. W. Harrow, lubricants supervisor, Dundee branch, has succeeded Mr. Davis as lubricants supervisor and assistant to Mr. McAulay, Scottish Oils and Shell-Mex, Ltd.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., announces that Mr. J. N. M. Legate, A.M.I.E.E., has been appointed manager, control gear engineering department (Manchester), of A.E.I. motor and control gear division. Mr. C. T. Scarf has been appointed chief control gear development engineer of A.E.I. motor and control gear division. Mr. O. T. Evans, A.M.I.Mech.E., M.I.E.E., has been appointed manager, and Mr. W. Spence, A.M.I.Mech.E., M.I.E.E., deputy manager, of the new plant applications engineering department of A.E.I. heavy plant division, Rugby.

THE METAL INDUSTRIES GROUP states that, following the acquisition by Metal Industries, Ltd., of Lancashire Dynamo Holdings, Ltd., the following board changes are announced: Sir Charles Westlake, chairman, and Mr. John Black, deputy chairman, of Metal Industries, have been appointed chairman and deputy chairman, respectively, of Lancashire Dynamo Holdings. Lt.-Col. G. S. Marston has resigned as chairman, managing director and director of Lancashire Dynamo Holdings. The Earl of Halsbury retains his office as vice-chairman of Lancashire Dynamo Holdings.

MR. H. F. H. SHIELDS has, on completion of fifty years' continuous service with the Mechanical Handling Companies of the Glover Group, accepted the position of Honorary President of British Ropeway Engineering Company, Ltd., relinquishing his chairmanship of that company to Mr. G. F. B. Harvey, one of the joint managing directors. He has also relinquished the managing directorship of Drag Scraper and Conveyor Company, Ltd., to which position Mr. M. Clayton has been appointed. Mr. Clayton is also technical and joint managing director of British Ropeway Engineering Company, Ltd.

STEEL, PEECH AND TOZER, a branch of The United Steel Companies, Ltd., announces the following staff changes: Mr. M. Thomas has been appointed assistant works manager (services) and Mr. E. Houghton has become assistant works manager (special duties). With effect from March 1, Mr. D. R. B. Burdass will become personal assistant to the general works manager, and on the same date Mr. D. Reilly will join the company as cold rolling mill manager. Mr. G. D. Jordan, who has been senior engineer in United Steel's department of operational research and cybernetics since its formation, will become Templeborough melting shop project secretary from March 1. Mr. J. Hewitt, of the research and development department of United Steel, has been appointed senior research metallurgist with effect from the same date. Mr. J. Ravenscroft joins the company on March 1 as arc furnace research assistant.

Business Announcements

CAWLEY PLASTICS, Ltd., Wey Lock Works, Byfleet Road, New Haw, Weybridge, Surrey, states that, as from March 1, the name of the company will be changed to Tough Plastics, Ltd.

ENGINEERING SURVEYS, Ltd., announces its intention to undertake site surveying and setting-out work under contract; its offices are at 53A, High Street, Ewell, Surrey (telephone, Burgh Heath 5342).

MR. C. W. SHARP, managing director, and Mr. L. Rumley, sales director, of Conveyancer Fork Trucks, Ltd., and Electro-Hydraulics, Ltd., have left this country for a business trip to the United States.

BRITISH ROPES, Ltd., states that its wire rope factory in Mexico, Cables Mexicanos S.A. de C.V., is to be expanded, and a new wire mill is being built to produce the necessary wire for rope-making, and to meet other specialised wire requirements in Mexico.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY, Ltd., (Telcon) announces that it is now the accredited agent for the sale of the Ford universal towing chock in the United Kingdom, and that this piece of equipment will ultimately be manufactured at Telcon Works, Greenwich.

RUBERY, OWEN AND CO., Ltd., Darlaston, South Staffs, announces that a new department in the motor division of the company, has been formed. It is to be called the trailer equipment department and will be under the joint management of Mr. J. T. Pierce and Mr. E. Pike, as from March 1.

F. PERKINS, Ltd., Peterborough, states that it has formed an overseas manufacturing operations division to investigate, organise and give advice on overseas manufacturing projects. Head of the new division is Mr. K. E. Woollatt, who has been appointed director of overseas manufacturing operations.

THE HARLAND ENGINEERING COMPANY, Ltd., B.E.P. Works, Alloa, Scotland, states that it is changing the operation of its separate wholly-owned subsidiary company, Harland Drives, Ltd., to a division of the parent company. As a first step to this end, the management of Harland Drives, Ltd., has been vested in the board of the Harland Engineering Company, Ltd., with effect from February 1.

D. NAPIER AND SON, Ltd., has concluded an arrangement with the Sierracin Corporation, Burbank, California, whereby it has exclusive rights to manufacture, use and sell the "Sierracin" and "Sierraglo" processes in Europe. "Sierracote" is a transparent resistance heating coating, the resistance of which can be controlled within a wide range (6–90 ohms per square), allowing irregularly-shaped windows to be deiced or demisted: it can be applied to glass or plastics materials. "Sierraglo" is an electro-luminescent technique giving light with a minimum evolution of heat.

BURTON, GRIFFITHS AND CO., Ltd., Mackadown Lane, Kitts Green, Birmingham, 33, announces an extension of its representation for the Gisholt Machine Company, Madison, U.S.A. As from March 1, it will be the sole concessionaire in the United Kingdom for Gisholt superfinishing machines and "Fastermatic" automatic-turret lathes. The company has also been appointed sole agent in the United Kingdom for Gisholt Machine Company (G.B.), Ltd., for the machines to be manufactured for them by Lang-Gisholt Machine Company, Ltd., at Johnstone, Scotland.

ALBERT MANN ENGINEERING COMPANY, Ltd., Basildon Industrial Estate, Essex, states that it has concluded a licensing agreement with Loma Machine Manufacturing Company, Inc., and its subsidiary, Lobeck Casting Processes, Inc., of New York City. The new agreement extends to the British Commonwealth, exclusive of Canada, and the Outer Seven countries of the European Free Trade Association. The company has also announced that it has taken over the whole of the share capital of Roll Race Conveyors, Ltd., and with it the right to manufacture and sell conveyors and handling equipment incorporating the patented Roll Race system of rolling loads.

Contracts

WILLIAM BOBY AND CO., Ltd., water treatment engineers of Rickmansworth, Herts, has been awarded contracts valued at £16,000 for dealkalisation/base exchange plants by George Wimpey and Co., Ltd., for the Union Carbide, Ltd., works at Hythe, Hants.

ASSOCIATED ELECTRICAL INDUSTRIES EXPORT, Ltd., has received an order for three geared gas turbine alternator sets of 2250kW each, using L.21 engines, to be installed at the deep water terminal at Fao of the Basrah Petroleum Company. The order is worth over £400,000.

TAYLOR WOODROW (CANADA), Ltd., has been awarded a 5,000,000 dollars contract to build a new head office near Toronto for Fords of Canada. This seven-storey building, with a total floor area of over 180,000 square feet, has been designed by Allward and Gouinlock, architects, of Toronto. It will be completed by April, 1961.

THE BRITISH GENERAL ELECTRIC COMPANY (PTY.), Ltd., Johannesburg, which represents The General Electric Company, Ltd., of England, in South Africa, has received contracts for two coal preparation plants worth approximately £230,000. The Chance sand flotation process will be employed in both installations and the plant will be supplied by G.E.C. The primary screening and conveying sections of the plant will be provided by Robins Conveyors (S.A.), Ltd., with which company the G.E.C. has close relations in this class of work. One plant will be situated at the Landau Colliery of the South African Coal Estates (Witbank), Ltd., and the second at the Kilbarchan Colliery of Natal Navigation Collieries and Estate Company, Ltd.

African Engineering News

By OUR SOUTH AFRICAN CORRESPONDENT

First Diesel Locomotive for S.W. Africa

THE accompanying photograph, shows the first of the Class 32 diesel-electric locomotives, of which 115 have been ordered by the South African Railways, to come off the assembly line at the works of the International General Electric Company of America, Erie, Pennsylvania. These locomotives are intended for the South West Africa system. Deliveries began at the end of last year.

The main specifications of these locomotives are :

Wheel arrangement	1–C_0–C_0–1
Total weight	95 tons
Horsepower for traction	1800
Driving wheel diameter	3ft
Overall length	55ft 4in

The diesel engine used is of the Cooper Bessemer type, F.V.12, having a " vee " arrangement of twelve cylinders. Engine factors are :

Stroke/bore	10½in/9in
Engine speed at full load	1000 r.p.m.
Compression ratio	12·7

First diesel locomotive for S.W. Africa

The engine develops 1980 h.p., of which 180 h.p. is absorbed by the various auxiliaries. The fuel tanks have a capacity of 958 gallons, which is enough for approximately 1000 miles under average conditions. The bogie frames are of cast steel and all axles are fitted with roller bearing axleboxes. The traction forces are transmitted to the body by bogie centres which carry the full weight of the body, and the couplers are located in the body underframe. The locomotive is equipped with air brakes, and the " Expressor," a combined exhauster and compressor, creates the vacuum for operation of the train brakes and the compressed air for the locomotive brakes.

World's Record in Mine Shaft Sinking

MANY factors have contributed to the spectacular increase in shaft sinking progress over the last ten years in the Union of South Africa, culminating, as it has just recently, in the creation of a new world's record.

The salient statistics of this new world's record at Vaal Reefs Gold Mining and Exploration Company, Ltd., compared to the previous record set up at the New Boutoff No. 3 Shaft, U.S.S.R., tabulated in the next column.

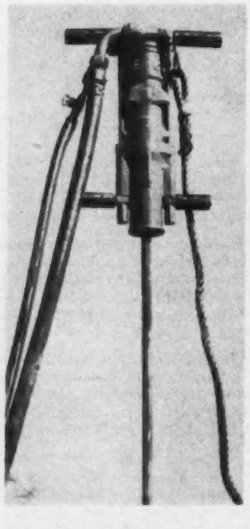
The development of mechanical mucking, especially the use of the mechanical grab, is one of the main features of this progress. The increase in rock-drilling performance has also contributed to the spectacular figure now attained of 922ft sunk in one month at the Vaal Reefs Gold Mining and Exploration Company, Ltd., during September, 1959.

The rock-drilling machines used at Vaal Reefs were the new S.E.C.O. S30 long-hole machines for pre-cementation cover hole drilling. These machines were designed and manufactured by The Steel Engineering Company, Ltd., Roodepoort, Transvaal, South Africa.

Performance	Vaal Reefs No. 2 shaft	New Boutoff No. 3 shaft, U.S.S.R.
Footage sunk in one month	922ft	868ft
Concrete-lined	940ft	—
Total tonnage excavated	55,240 tons	24,820 tons
Excavated diameter	28ft	21·65ft

It was decided just over a year ago that the new S.E.C.O. S27 sinker should be designed and made. It was specifically decided also that the new machine should, as far as possible, improve drilling performance sufficiently to make a new shaft sinking record feasible when used in combination with the latest equipment and techniques used in South African shaft sinking.

The drilling performance at Vaal Reefs Gold Mining and Exploration Company, Ltd., indicates that these requirements have been met. Drilling times per round in lava have decreased from around sixty to seventy minutes to approximately forty to fifty minutes on a 7ft 6in round as compared with the previous S.E.C.O. S24 sinking machines used on previous shaft sinking records set up in South Africa. The following is a summary of these records.



Sinker used at Vaal Reefs

In 1953, Vlakfontein Gold Mining Company, Ltd., using the S.E.C.O. S24 machines, broke the world's record, the figure being 585ft in thirty days. Subsequently, the undermentioned mines, broke world's records as follows : — 1954, Hartebeestfontein Gold Mining Company, Ltd. ; 1955, Merriespruit Gold Mining Company, Ltd.; 1956, West Rand Consolidated Mines, Ltd.; 1957, Harmony Gold Mining Company, Ltd. ; 1957, Free State Saiplaas Gold Mining Company, Ltd.

Use of Rubber in Railway Tracks

DURING recent years most railways have been exploring the possibilities of improvements in track and alternative forms of construction such as, for example, the concrete sleeper. The main disadvantage of this type of sleeper is that it possesses very little elasticity, so that some form of shock absorber is required to provide resilience and to prevent the concrete from breaking up due to the impact loads from rolling stock.

Much experimental work has been done, and it was the French Railways which were the first to find a satisfactory answer in the shape of the grooved rubber pad. Prior to the introduction of the grooved pad, solid pads had been used, but due to the thickness required their cost was high. The grooves provide space for the rubber to expand and the present pad, which is 4mm–5mm thick is considered to be equivalent to a solid pad of 20mm in thickness. In France the most satisfactory fastening has been found to be a grooved rubber pad under the rail with an elastic steel clip to clamp down on the top of the rail flange.

Other railways have followed the same basic principle, and rubber is now widely used as the cushion between rails and concrete sleepers. On the South African Railways, 30,000 sleepers on the French principle have already been supplied and are in service and orders for another 270,500 are being executed. Also, 500 sleepers on a German principle have already been supplied, and orders for 30,000 sleepers on a Swedish principle are being executed. In all cases rubber pads are used, 662,000 being required for all the above sleepers.

Up to the time of the experiments with concrete sleepers it was well known that trains set up vibrations in the track, but it was not known that in addition to these obvious vibrations there existed in the rail itself high frequency vibrations which are not apparent in the normal way. Arising out of the experiments with concrete sleepers the presence of these high-

A neoprene pad in position

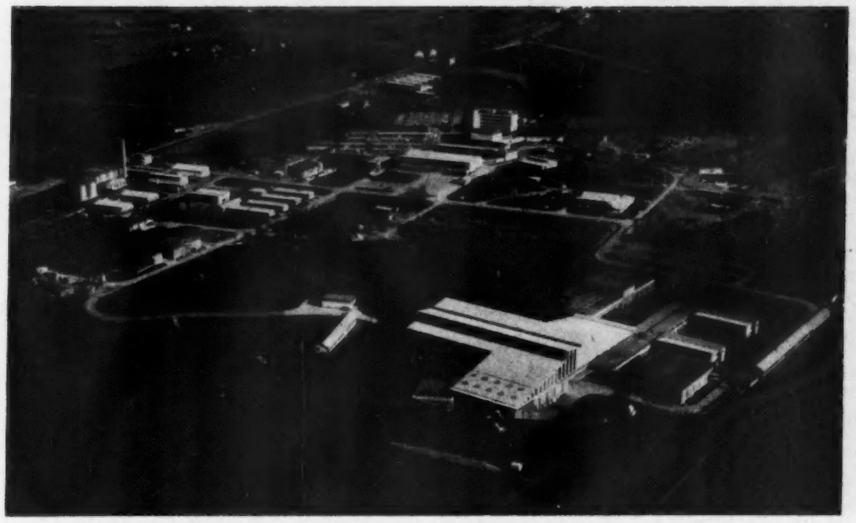
frequency vibrations was discovered, and it was found that they were largely responsible for the deterioration of the rigid fastenings then used. This has resulted in a swing over in many countries to various types of resilient track. The extent of resilience required varies mainly in accordance with the speed of trains on that particular railway and each railway must ascertain by tests to what extent resilient track is required. On the South African Railways there is a total of about 10 miles of various types of resilient track under test, embodying about 30,000 rubber pads.

The illustration above shows a neoprene pad in position. It should be noted that this is used also as an insulator to permit of the rail being used for electrical signalling purposes.

The South African Railway Administration has been working in co-operation with the Natural Rubber Development Board on the question of the use of natural rubber in connection with the introduction of concrete sleepers.

CONTINENTAL AFFAIRS

by Our Continental Editor

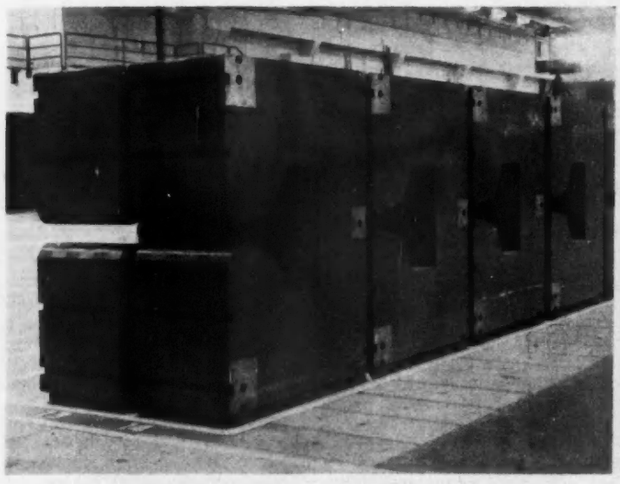


CERN Proton Synchrotron

No. II—(*Concluded from page 278, February 12*)

The 25 GeV proton synchrotron is the second particle accelerator to go into operation at the Meyrin, Geneva, centre of CERN, the European Organisation for Nuclear Research. The first CERN accelerator, a 600 MeV synchro-cyclotron, was built in 1957. The proton synchrotron, which is described below, was designed in 1954 and became operational last year. It is the first machine of its kind to use the alternating gradient principle with strong focusing and an enormous saving in the weight of magnet steel. It has already produced particles with an energy of 28·3 GeV and beam intensities higher than expected.

IN last week's issue it was explained that the protons to be accelerated in the ring-shaped vacuum chamber of the proton synchrotron originate from an ion source. Before being injected into the synchrotron these particles are subjected to preliminary acceleration: the equipment is shown schematically in the diagram overleaf. Protons from the ion source are first accelerated to about 500 keV in a Cockcroft-Walton generator and are then injected into an Alvarez linear accelerator. There the beam of protons has its energy raised to a level of 50 MeV and after passing through four-pole focusing lenses and a "debuncher" is deflected magnetically and electrostatically to enter the ring-shaped vacuum chamber of the synchrotron proper. At this stage the protons come under the influence of (*a*) a series of sixteen r.f. accelerating cavities spaced more or less equally round the ring, and (*b*) a rapidly rising magnetic field. Expressing the process in simple terms the combined influence of the acceleration and the rising magnetic field keep the proton beam in a circular mean orbit.



"Closed section" magnet blocks for CERN proton synchrotron

Focusing is necessary to preserve beam intensity. In synchrotrons the usual method of focusing is to give the magnetic field a radial gradient: the field strength decreases with radius and thereby opposes any deviations from the circular orbit. In practice the magnitude of this focusing effect is somewhat limited, the free oscillations of the protons are of comparatively large amplitude and the cross sectional dimensions of the vacuum chamber and the magnet gap are correspondingly large.

By applying the alternating gradient principle, however, much stronger focusing can be achieved and the amplitudes of oscillation of the protons can be made as small as required. This effect is obtained by reversing the direction of the gradient in adjacent sections of the magnet around the circumference of the ring. Because of the stronger focusing the dimensions of the magnet are substantially reduced. In the CPS magnet the aperture housing the excitation winding is only 14cm by 7cm and the weight of steel is 3400 tons. The Russian 10 GeV "Synchrophasotron" magnet, on the other hand, has an aperture 150cm by 40cm high and contains 35,000 tons of steel.

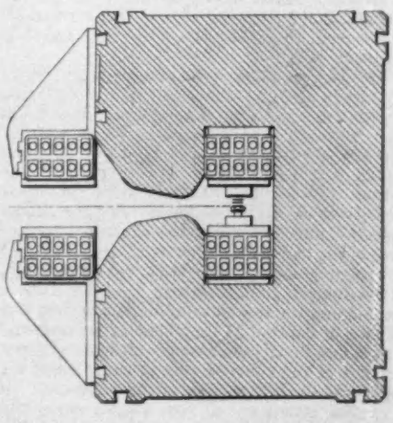
However, these advantages of strong focusing can only be gained at the expense of very much tighter tolerances in the manufacture and alignment of the magnet sections and in the permissible physical changes in the completed structure during its working life.

Magnet System

The CPS magnet is built up of 100 nominally identical magnet units each 430cm long circumferentially. For a given magnetising current the acceptable variation in magnetic field as between one magnet unit and another was specified to be 0·1 per cent. In setting up the magnet units the alignment tolerances were 0·3mm, r.m.s., vertically and 0·6mm, r.m.s., horizontally on a mean radius for the magnet structure of 100m.

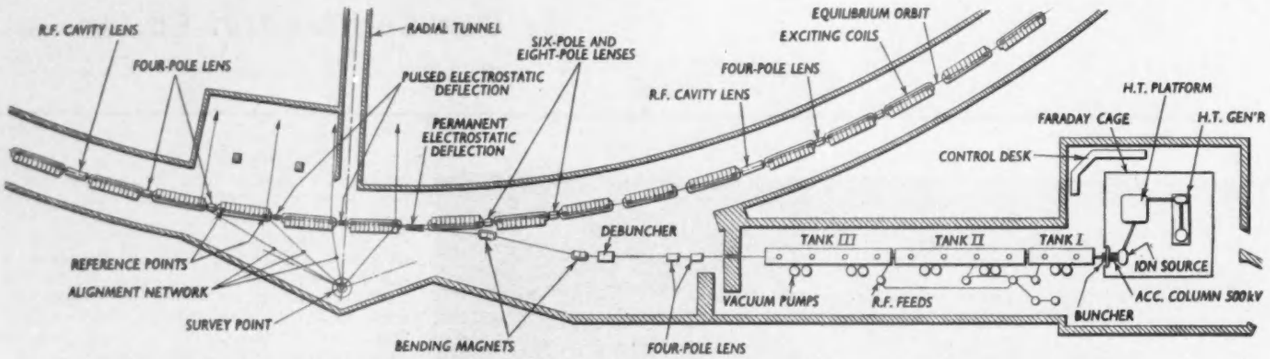
Each magnet unit is built up of ten C-shaped blocks, each 42cm long axially. The blocks are of two kinds. Those shown in the photograph reproduced here are "closed-section"; those shown in the drawing are "open section." By assembling five blocks of each kind the resulting magnet unit consists of a focusing half sector and a defocusing half sector. The blocks are parallel-faced and the magnet unit is made arc shaped by providing wedge-shaped air gaps between adjacent blocks.

To achieve the specified magnetic tolerances



Section through "open" magnet block and excitation winding

CONTINENTAL AFFAIRS *(Continued)*



Schematic diagram showing the preliminary acceleration and injection system and part of the magnet ring of the CERN proton synchrotron

some interesting refinements were introduced in the manufacturing and assembly processes. The magnet steel was made from selected ingots of low carbon steel of specially controlled chemical composition. After the normal hot rolling strip of the required final thickness (1·5mm, to limit eddy currents) was produced by carefully controlled cold reduction.

This strip was cut into sheets about 1m square, stacked in piles and annealed before being oiled, packaged and delivered to the magnet block maker. The block maker stacked the packages in such a way that the variation in coercive force between the packages in a stack was much less than ±0·1 oersted, although the variations between the stacks could be greater. The number of stacks was made the same as the number of laminations in a block. After the store had been filled each block was assembled by taking the top lamination from each stack in sequence, punching the laminations in the same sequence and assembling them with interleaved paper insulation and "Araldite." Since there are 264 laminations (one from each stack) in a magnet block, the variations in coercive force between blocks are $1/\sqrt{264}$ times the spread of coercive force in a stack.

Accurate comparisons at fields of about 3000 gauss showed that the mean field measured along the axis of the block differed from that of a reference block by 0·02 per cent; at the point of injection (147 gauss) the difference was 0·05 per cent.

Each magnet unit has an excitation winding on the upper and lower pole pieces as illustrated Each coil consists of two five-turn pancakes of aluminium conductor (55mm by 38mm) with a central hole of 12mm diameter for cooling. All the 400 pancake coils are connected in series electrically and in parallel for cooling. Electrical insulation is provided by mica sandwiched between two layers of paper, the whole being vacuum impregnated with a polyester resin.

Magnetic lenses and pole-face windings are included in the magnet system so that corrections can be made for any deviations from the specified magnetic field.

The magnet units rest on steel beams which are supported by a jacking system on a reinforced concrete ring of 200m diameter and 2m by 2m cross section. As illustrated in the perspective drawing, this ring is carried by elastic supports set in concrete columns which penetrate the subsoil and are cast into the rock formation underlying the site. The ring carrying the magnet system is therefore a separate structure independent of the tunnel and other buildings. To avoid temperature differential effects, the temperature in the tunnel is controlled within ±1 deg. Cent.; the ducting for the air conditioning system can be seen in the roof of the tunnel in the drawing. As an additional refinement a number of pipes are cast in the concrete ring to carry water for regulating the temperature of this structure.

In the setting-up of the magnet units the alignment tolerance aimed at was ±1 in 10^6. The main criteria from the viewpoint of the stability of the foundations were the spatial harmonics of the possible distortions. It was calculated that the sixth harmonic would be critical, since a disturbance of 0·3mm amplitude would cause a deviation of 1cm in the closed orbit.

It was proposed to obtain alignment accurate to 1 in 10^6 by triangulation surveying, based on the best available theodolites and suitably aged Invar wires. The scheme was to set up a central survey point at the geometrical centre of the ring and then, using radial tunnels, to establish a number of survey points on the ring. A hexagonal system had to be avoided because of the extreme sensitivity of the synchrotron to sixth harmonic distortions, as mentioned above. Accordingly, an octagonal layout was adopted, with eight equally-spaced radial tunnels. One of the eight survey points and part of the associated radial tunnel can be seen in the above drawing. Orthodox surveying methods can be used to align any of the magnet units from one of the eight survey points.

Accelerating System

The function of the r.f. accelerating system is to ensure that the frequency of the accelerating voltage matches the steadily rising magnetic field with great precision, so that the particles will be kept near the centre of the cross section of the vacuum throughout the accelerating cycle. The permissible error in frequency is about 0·1 per cent at injection and 0·01 per cent at ejection, but the requirement is much more stringent (of the order of 0·0001 per cent) in the region of the "transition energy," about 5 GeV in this machine, where a phase jump occurs.

In the CPS this accurate control of frequency is achieved in two stages. First, from the injection energy of 50 MeV up to energies of about 1 GeV the frequency of the accelerating voltage is automatically controlled in accordance with the instantaneous value of the magnetic field by an analogue computer. Secondly, when the particles have been firmly held in phase-stable bunches, which happens at about 100 MeV, another frequency control system is switched in to supplement the analogue computer. This second system makes use of pick-up electrodes to detect the relationship between the phase of the bunches of particles in the vacuum chamber and the phase of the accelerating r.f. voltage; a servo system then keeps this phase difference constant at a stipulated value. At the same time the radial positions of the bunches of particles are detected by other pick-up electrodes and an associated servo system keeps the bunches in the centre of the cross section of the vacuum chamber.

In this control scheme* the method of measuring the instantaneous value of the magnetic field is based on the Hall effect and automatically allows for the effect of the remanent field. The resulting signal is fed into the analogue computer where it is converted into a signal corresponding to the predetermined law connecting accelerating frequency and magnetic field. The output signal of the electronic computer then acts on the main oscillator; this device gives a basic accuracy of the order 10^{-3} to 10^{-4} which has to be improved by a correcting signal originating from the beam. The r.f. signal obtained is then injected after adequate pre-amplification into the distributing amplifier placed at the centre of the machine, and thence cables of equal electric length transmit the r.f. voltage to the sixteen accelerating stations placed around the ring.

The oscillator contains, as its frequency determining element, a linear frequency-voltage converter. The output of a conventional f.m.-oscillator is connected to a frequency meter giving an output voltage V' proportional to its input frequency f. This voltage is compared with the controlling voltage V produced by the Hall computer, and the difference is amplified and fed back to control the f.m.-oscillator.

Each of the sixteen accelerating stations distributed around the circumference comprises (*a*) a resonator with an accelerating gap; (*b*) an automatic frequency tuning device; (*c*) a power amplifier. The resonator consists essentially of two push-pull quarter-wave coaxial lines. The protons travel in the space enclosed by the inner conductor and are accelerated when going through the gap in the middle of the station. To house the resonating cavity in the section situated between two magnet units, its length must be reduced to fit into the available space; this is done by loading the cavity with ferrite, which also permits automatic frequency tuning.

In each accelerating cavity the two quarter-wave resonators are excited in phase opposition, allowing push-pull operation at the accelerating gap. One of the resonators is fed by a loop directly connected to the plate of the power supply, the excitation in phase opposition of the other resonator being effected by means of a figure-of-eight coupling loop. Each of the two ferrite cores contains forty-five ferrite discs, 2·1cm wide, glued together with "Araldite." Tuning of the cavity is achieved automatically by acting on the d.c. current feeding an auxiliary magnet which encloses the cavity.

The accelerating units are placed in the ring, where the temperature is kept constant to ±1 deg. Cent. Cooling by radiation and convection would be inadequate, and the ferrite cores and all the power tubes are therefore water cooled.

Magnet Power Supply

The main requirements for energising the magnet of the proton synchrotron are that the magnetising current must be increased smoothly from zero to 6400A in 1·1 seconds and then reduced to zero in 1 second during which time the magnet voltage must be kept constant within ±0·2 per cent. The peak power of 38·4MW is obtained from a turbo-alternator driven by a motor, the speed of which is governed by an electronically-controlled Scherbius set.

To avoid intolerable fluctuations in the demands on the public supply system the inertia of the

* The following description is based on an article by E. Regenstreif in *CERN'S 25 GeV Proton Synchrotron*, published by CERN, Geneva, 23.

rotors is increased by a direct-coupled 6-ton flywheel. This rotating system stores the energy produced when the magnet is being de-energised and returns it during the first part of the magnetising cycle. A bank of twenty-four grid-controlled mutators controls the interchange of energy between the magnet and the alternator set.

The choice of a two-pole solid-rotor machine for the alternator offered the advantages of greater kinetic energy and lower sub-transient reactance than in a multi-polar machine. The second consideration was important because of its beneficial influence on rectifier commutation. The main particulars of the alternator are: speed 3000 r.p.m.; voltage 6890V; frequency 50 c/s; power factor 0·92; peak output 46·8MVA; peak current 3920A (exciter current 745A, voltage 123V); continuous output 18MVA; continuous current 1510A (exciter current 500A, voltage 83·5). The alternator supplies the rectifier through a transformer.

The induction motor has to supply the average losses of the installation, including reversal of the magnetisation of the magnet, I^2R losses in the excitation windings, friction and windage losses and transformer and rectifier losses. The motor rating is 2600kW, 6kV, 50 c/s, 2975 r.p.m., power factor 0·91.

Changeover from rectification to inversion, after the magnetisation peak, is effected in two stages, to avoid unnecessary oscillation being introduced into the alternator rotor and flywheel system. The main function of the delay period is to keep the current constant for a definite period to allow the particles in the accelerator to make increasing orbits so that they can strike targets in the vacuum chamber. As this changeover must be very accurately timed, separate grid control sets are provided for rectifier and inverter operation and the changeover is controlled electronically.

Power is taken from the public supply system through three 18kV cables, each of 7MVA rating. Two substations supply the proton synchrotron area. One is in the power station housing the generator set. It supplies the generator set (through a step-down transformer) at 6kV and the r.f. accelerating system at 3kV and provides low voltage to the area.

Operating Experience

Operational experience with the proton synchrotron were described by Mr. J. P. Adams in an article in *CERN'S 25 GeV Proton Synchrotron*, from which the following particulars have been abstracted.

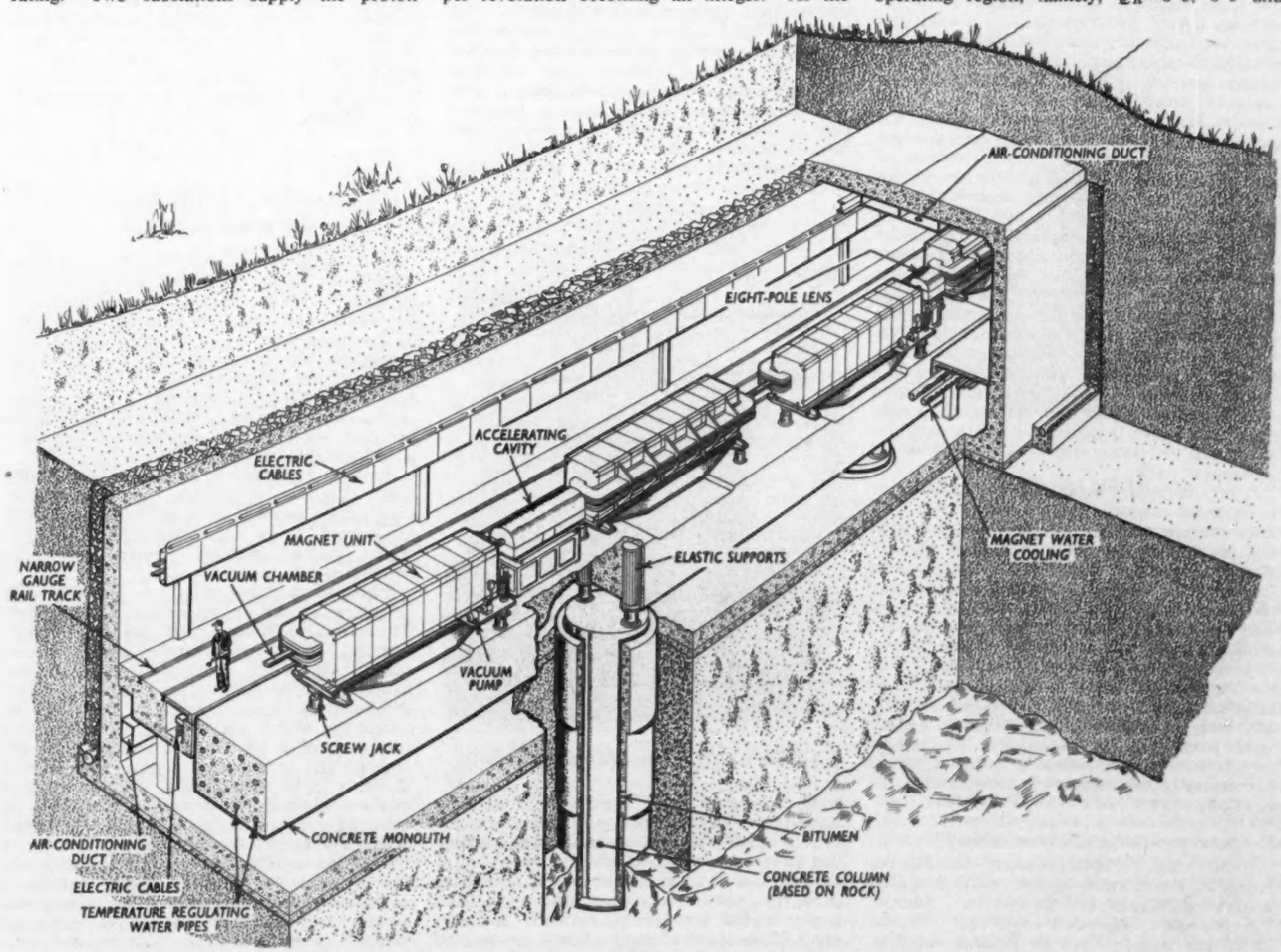
Measurements so far carried out on the CPS are necessarily preliminary and incomplete. It will take at least six months of measurement work before sufficient is known about the behaviour of the machine to exploit it as a working nuclear physics tool.

The intensity of the proton beam is surprisingly high at this early stage of operation.

The CPS linear accelerator has produced intensities up to 5mA peak, although for the tests so far carried out with the synchrotron a collimated 1mA proton beam has been employed. A buncher and debuncher have been built for this linear accelerator, but neither have been used so far. With 1mA being injected into the synchrotron and single turn injection, a capture efficiency of 20 to 25 per cent has been measured, corresponding to a circulating beam of 10^{10} protons per pulse. The pulse repetition rate at 25 GeV is twenty a minute.

The energy of the protons in the synchrotron has, so far, been calculated from the magnetic field at the time the beam disappears and the radius of the machine. The earliest operational runs were carried out without any of the correcting devices being employed, except for the self-powered pole-face windings needed to correct eddy currents in the metal vacuum chamber at injection, when the guiding magnetic field is only 140 gauss. The proton beam then disappeared at a magnetic field of about 12 kilogauss due to the number of free oscillations of the particles per revolution becoming an integer. As the magnet yoke saturates, the focusing forces diminish slightly, and instead of the machine working in the stable region between the unstable resonance bands, the operating point is slowly forced into a resonance and the particles are lost to the walls of the vacuum chamber. In later runs the pole-face windings were energised by programmed generators designed to keep the focusing forces constant up to magnetic fields of over 14,000 gauss and it was observed that all of the proton beam then reached an energy of just over 28 GeV, limited only by the peak magnetic field available in the CPS.

An attempt has been made to measure the number of free oscillations per revolution in both the axial and radial directions (Q_V and Q_R) during the acceleration cycle. At injection, with the pulsed inflector voltages not energised and a 2μs pulse of protons injected from the linear accelerator, the beam spirals inwards in radius, due to the rising magnetic field, for over 100 microseconds, and the fractional Q-values can be observed in the two directions by pick-up electrodes sensitive to one or the other of the two directions of oscillation. For these measurements the beam is injected in such a way as to set up either axial or radial oscillations of the particles. During the acceleration cycle the Q-values were measured by pulsing the quadrupole correcting lenses at different times in the cycle and by variable amounts, and noting when the beam was lost. The nominal Q-values are both about 6·25, and if at a certain moment the quadrupole lenses are pulsed by an amount that shifts, say, the Q_R value to 6·0, the beam will be lost due to instability at a radial second-order resonance. Similarly, pulsing the lenses in the opposite direction by the same amount loses the beam due to instability at a radial first resonance. Apart from the shift of the Q-values when the magnet saturates, it appears that they remain close to $Q_V=6·3$, $Q_R=6·2$, during most of the acceleration cycle. Using this same method, the unstable boundaries of the stable operating region, namely, $Q_R=6·0$, 6·5 and



Perspective of ring accelerating chamber of CERN proton synchrotron

CONTINENTAL AFFAIRS *(Continued)*

Q_F=6·0, 6·5, have been measured. So far, no higher order resonances due to non-linear instabilities have been observed, although whether this is a tribute to the linearity of the machine or due to the crudeness of the measurements remains to be seen.

Measurements have been made of the closed orbit displacement at twenty points around the circumference of the machine, from which the closed orbit amplitude and shape have been computed. The closed orbit is that orbit around which all particles perform free oscillations. In a perfect machine without field-free sectors it would be a perfect circle in a plane. In an imperfect machine its shape and amplitude are due to the imperfections. At injection the peak-to-peak amplitude of the closed orbit in the radial direction is about 4cm, and in the axial direction it is a few millimetres. Later on in the cycle the peak-to-peak amplitude diminishes in the radial direction to about 1cm and remains negligible in the axial direction. Since the vacuum chamber dimensions are 14cm in the radial direction and 7cm in the axial direction, there is therefore no danger of beam loss due to magnet misalignments.

The transition energy, which seemed so formidable a barrier during the design stage, proved to be easily surmountable in practice. The precision of phase switching needed at transition for no noticeable loss of particles was found to be about ±3 milliseconds, or ±36 gauss.

Both the computer and the beam control system for determining the frequency of the accelerating voltage have proved very satisfactory after minor adjustments. During the operational runs so far carried out the beam control system has been switched in about 1ms after injection and there seems to be no noticeable loss of particles during this switchover. During the early acceleration studies the radial control servo acted on the amplitude of the accelerating voltage, which in principle is equally effective a means of controlling the radial position of the beam as varying the phase or frequency of the accelerating voltage. This arrangement was not successful, perhaps due to a certain amount of jitter in the phase-lock loop, and the system was modified so that the radial control servo acted on the phase of the accelerating voltage. This second method was completely successful and no particles were lost during acceleration. Preliminary measurements indicated that the beam was not moving more than 1cm from the centre of the vacuum chamber during the acceleration cycle. The beam control system depends for its operation on the presence of a bunched proton beam, and, due to noise in the servo loops, there is a certain minimum value for the circulating beam current, below which the system no longer maintains control. It appears from early measurements that the system will work with about 10^8 protons per pulse.

A very important parameter of an accelerator is the mean intensity. At an energy of 6 GeV the mean intensity of the CPS is now nearly as high as that of the Bevatron, and at 10 GeV considerably higher than that of the Russian machine. It is hoped to increase the intensity of the CPS by an order of magnitude by bringing into operation the buncher and debuncher of the linear accelerator and allowing more protons to be injected into the synchrotron. At 25 GeV the yield of secondary particles from internal targets is considerably higher than at 6–10 GeV, and early measurements of secondary particle yields from the CPS indicate that the machine may be a strong competitor to the lower-energy high-intensity machines now being built from this point of view (see page 277, February 12).

Participation in Proton Synchrotron Project

CERN, the European Council for Nuclear Research, has thirteen member states and their financial participation is as follows: Austria, 1·93 per cent; Belgium, 4·15 per cent; France, 21·22 per cent; German Federal Republic, 19·52 per cent; Greece, 1·17 per cent; Italy, 10·09 per cent; Netherlands, 3·85 per cent; Norway, 1·61 per cent; Sweden, 4·23 per cent; Switzerland, 3·29 per cent; United Kingdom, 25 per cent; Yugoslavia, 1·95 per cent. The annual budget has increased from £2,090,000 in 1955 to £5,417,000 in 1960. The total staff of CERN numbers 969.

The cost of the 25 GeV proton synchrotron is estimated at £10,000,000.

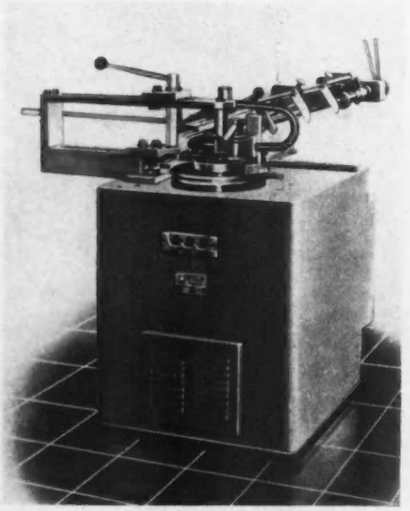
The main participants in the construction of the proton synchrotron were:

Architects, R. and P. Steiger; engineers, Fietz and Hauri; consulting engineers, Professor G. Schmitter, D. Bonnard, R. Spieser, Engr. H. Wegmann (Switzerland). Civil engineering contractors, Guffanti, Italy, Gandoni, Vandoni, Italy, and Zschokke, Spinedi, Losinger. Magnet blocks and metadyne sets for lenses, Ansaldo San Giorgi, Italy. Aluminium for magnet coils and busbars, Aluminium Chippis, Switzerland. Magnet coils and busbars, pole-face windings, 6 and 8-pole lenses, m.g. sets for testing magnet units, A.C.E.C., Belgium. Magnet steel, Società Italiana Acciaierie Cornigliano, Italy. Magnet cooling system, Zimmermann, Germany. Magnet power supply plant, including Scherbius control, rectifiers, h.v. switchgear and control board, Brown Boveri and Co., Switzerland. Vacuum chamber, pick-up electrode tanks, Gallay Jean (Usines), Switzerland. "Linac" linear accelerator and vacuum system, Metropolitan-Vickers Electrical Company, Ltd., U.K. 600kV Cockcroft-Walton generator for pre-injector, Haefely, Switzerland. High-voltage generators, SAMES, France. Valves and accessories for accelerating stations, English Electric Company, Ltd., U.K. R.f. accelerating units, Magneti Marelli, Italy. Bending magnets, quadrupole lenses and m.g. sets, Oerlikon Engineering Company, Switzerland. Electronic equipment and ferrite for r.f. cavities, Philips, Netherlands. Quadrupole lenses and power supplies, Rade Koncar, Yugoslavia. Vacuum pumping stations, Gerätebau-Anstalt Balzers, Liechtenstein. Corrugated bellows for vacuum system, Metallschlauchfabrik, Switzerland. Air conditioning for P.S. ring and generator building, Tunzini, France. Control system for air conditioning in P.S. ring building, Honeywell Brown, U.S.A. Pipes for cooling systems, Curvat, Millet et Cie, France. Structural steelwork and lifting equipment in P.S. buildings, Ateliers de Constructions Mécaniques de Vevey, S.A., Switzerland. Transformers, Ateliers de Sécheron, S.A., Switzerland. L.v. switchgear, power distribution cables, &c., Siemens-Schuckert, Germany.

Tube Cold-Bending Machine

An addition to the range of "Lang" tube cold-bending machines is now available. The Model "EL75," shown in our illustration, has a maximum capacity of 3in outside diameter by 14 S.W.G. wall thickness. The maximum bending radius is 14in for standard tools, while with the special attachment there is no upper limit. Actual bending time for a 90 deg. bend for each model is stated to be five seconds.

In addition to round tubes it is possible to bend rectangular, oval, square and irregularly shaped tube, solid sections and standard sections such as angles, tees, and channels. The machine will form either right- or left-hand bends and if required can be supplied with overhung bending table for greater versatility. Any angle from 0 deg. to 180 deg. can be obtained, and with an additional attachment bends up to 360 deg., for rings and helical coils can be made.



Model "EL75" tube cold-bending machine

A novel detail is a special bending attachment that will enable the radii required to be selected at will, the minimum radius being approximately five times the outside diameter of the tube. Although each size or section of tube still requires a separate set of tools, the same set of tools is used for different radii. For repetition bending, the "programme bending attachment" makes multiple bends in one component by setting the lengths between successive bends. Each length of tube can be brought up to the stop ensuring that the straight portions will be of uniform length. The programme bending attachment is fixed to the mandrel holder. If the component has different bending angles the provision of additional swing-up stops avoids a resetting of the angle stops.

The tubes are bent cold over an internal mandrel which completely fills and thus supports the internal diameter. Tools are easily and quickly interchangeable. The stationary bearing plate has a circular scale reading 0 deg. to 360 deg.

The steel driving plate on which is fixed the bending tool is fitted with two stop pins which are adjustable to give any setting from 0 deg. to 180 deg. These pins contact the limit switches and control the cycle. When the required angle is attained the machine is automatically brought to a dead stop by the electromagnetic brake. The mandrel return device withdraws the mandrel at the end of the stroke to facilitate removal of the bent tube. The tool then returns to the starting position.

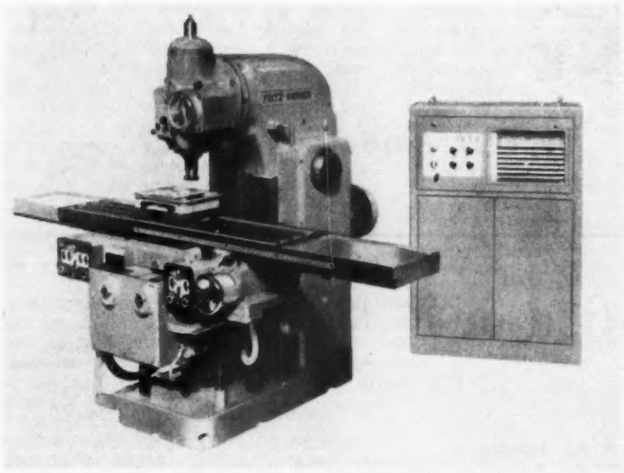
The machine is equipped for hand control, but foot-operated switches which have the advantage of leaving the operator's hands free can be supplied. The circuit is arranged so that the machine cannot run unless the bending arm is in the correct starting position, and is interlocked to prevent damage by incorrect operation. Agent in the United Kingdom is Embassy Machine and Tool Company, Ltd., 248, Watford Way, Hendon, London, N.W.4.

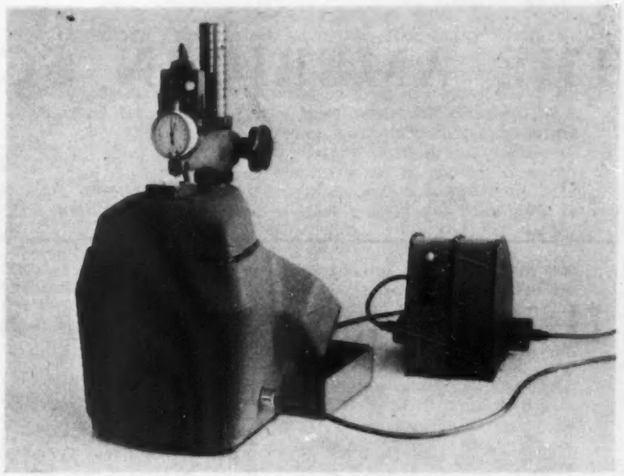
Automatic Compensation of Reactive Current

In electricity supply systems of factories, it is usual to correct the power factor near the main busbars by means of automatically switched batteries of condensers, or at individual motors by means of separate condensers. The disadvantage of the first solution is that only the portion of the system external to the factory is kept free from reactive current. The second arrangement is found to be economically justified only where the unit concerned is large and is in constant operation.

A third possibility is to correct the power factor of groups of motors, thereby striking a compromise between the lower installation cost for overall power factor correction, and the higher savings possible through individual correction.

Siemens-Schuckertwerke A.G., Berlin and Erlangen, has put on the market a unit system for automatic power factor control of sub-circuits. The system comprises reactive power relays, air circuit breakers, fuses, indicator lamps, and control switches for setting to either automatic or manual operation. The units are completely wired and housed in sheet steel casings suitable for rough conditions. By the combination of a central control with control elements in the sub-circuits, a fine regulation of the total condenser capacity is claimed to be achieved. The condensers of the individual stages correspond to the steps of the control installation e.g. 50kVA. It is stated that the use of these control units makes possible a substantial load reduction of the distribution system, with resultant savings in particular where supply agreements favour users who maintain a high power factor.





(Left) Vertical milling machine with push-button three-dimensional programme control. (Right) Sorting device allowing components to be inspected and classed into three groups (oversize, undersize and correct), with limits set to within 0·00004in. Horizontal and multiple indicators can alternatively be used with the sorting machine

Programme-Controlled Milling Machines

Particulars have been received of a range of automatic three-dimensional programme-controlled vertical and horizontal milling machines with tables from 43in by 12in to 98in by 24in, now being made by Fritz Werner A.G., of West Berlin, Germany. One of the new machines with its control cabinet is shown in the illustration, above, left.

On the upper left-hand front part of this cabinet there is situated the main twenty-station control panel which incorporates the master switch and selector switches for the direction of spindle rotation, coolant supply, &c. Up to four banks of push buttons determining the sequence of the machining programme enabling a maximum of eighty stages to be covered can be included in the cabinet. Twenty vertical rows of fifteen buttons compose one bank, and through these buttons the programme stages are carried out in the numbered sequence. As each stage is initiated the corresponding number is illuminated.

The function performed at each stage is selected by depressing the appropriate button in the vertical row, an identifying symbol being provided at the end of each horizontal row.

The top row of push buttons is used to select milling spindle rotation and the subsequent rows, two to thirteen, select the feed and rapid traverse motions in both directions of movement for the table, saddle and knee. Buttons in row fourteen are used for interrupting the programme at any desired stage, such as for cutter changing after which the programme is restarted by a push button mounted on the machine saddle. The end of the programme cycle is selected by the buttons in row fifteen.

Trip dogs on interchangeable carrier plates secured to the table, saddle and knee control the lengths of traverses in each direction of motion. The use of these interchangeable carrier plates, together with push button masking templates, makes a machine equally suitable for small and large batch production as change-overs can be effected in a few minutes.

The Rockwell Machine Tool Company, Ltd., Welsh Harp, Edgware Road, London, N.W.2, handles the machines made by Fritz Werner A.G., in this country.

Semi-Automatic Sorter

While equipment for the automatic sorting of precision parts has been available for some time, the considerable cost of it meant that its installation could only be justified where batches were very large. A simpler sorting device of a semi-automatic kind has been produced by Compac Works, Geneva-Châtelaine, and is being distributed in this country by H. Williams and Son, Ltd., Lark Works, Sandridge Road, St. Albans, Herts. The speed of the equipment is claimed to be such that it can take the place, in certain cases, of a larger automatic machine. It is stated to ensure a high degree of safety in the inspection process by eliminating errors due to distraction, fatigue, or misinterpretation of readings.

Conventional inspection comprises at least five separate successive operations: insertion of the component into the measuring device, taking a reading, evaluation of the reading and remembering it, withdrawal of component and placing component into the correct container. With the "TR.1" apparatus, it is only necessary to insert the component, and allow it to fall into the opening of the sorting machine.

Our illustration shows the arrangement. The indicating and switching head is set on an arm mounted adjustably on a vertical column, so that the gap between the indicator plunger and the anvil can be varied to suit the component. Behind the anvil is an opening through which the tested component falls into the sorter. This contains two gates which are appropriately set by the limit switches of the indicator and by two rotary electromagnets so as to allow the component to fall into one of three trays corresponding to the three size ranges selected. The outlet chutes are rectangular and measure approximately 2in by 1¾in.

The accuracy of the sorter is stated to be such that it can be used in conjunction with measuring instruments reading down to 0·00004in.

When specially high speeds are necessary the parts can be more quickly introduced by means of loaders. Alternatively, the installation can be made wholly automatic by incorporating mechanical feeders.

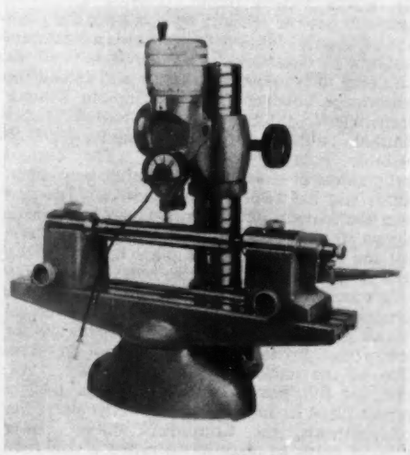
Instead of mounting a single indicator on a vertical column as illustrated, any other convenient arrangement can be used, including multi-inspection devices for testing two or several dimensions simultaneously.

European Agricultural Machinery Manufacturers

The first general assembly of the Committee of European Manufacturers of Agricultural Machinery (C.E.M.A.) has recently been held in London. It was attended by forty delegates representing the United Kingdom, Austria, Belgium, France, Western Germany, Holland, Italy and Switzerland. The committee, it should be explained, is a free association of various national organisations, membership being open to all countries of Western Europe. The principal task of the recent assembly was to establish working parties to study problems of mutual interest. Five working groups were set up to consider: international fairs and exhibitions; terminology and statistics; agricultural machinery tests; economic expansion, and measures to correlate such important matters as accident prevention, the training of technicians, the working of international patent provisions and exchange visits between the various member-countries.

Precision Measuring Equipment

We illustrate a precision dial test indicator equipment made by Hahn and Kolb, of Stuttgart, which is now being marketed by Optical-Mechanical (Instruments), Ltd., 17, Station



Precision dial test indicator

Road, Egham, Surrey. The instrument incorporates a large micrometer reading direct to 0·0001in (2 or 5 microns) and having its index line specially corrected to compensate for any slight pitch errors over its whole length of travel of 2in to an accuracy of ±0·00005in. The measured length is shown in a window below and to the left of the micrometer drum and on a scale of 5 : 1 magnification. With the aid of one slip gauge only of 4in length, the instrument is stated to be capable of being set for work-pieces up to 6in high.

Using the micrometer setting, tests can be carried out with dial indicators over a length of travel of 2in with one setting. An attachment, shown in our illustration, is interchangeable with a lapped circular measuring table and used for between-centres concentricity tests. The indicator has a quick-release cable which operates its spindle. The head can be positioned quickly on the column by a crank drive within the wide measuring range in readiness for the precision micrometer setting.

THE AMERICAN SCENE

by Our American Editor

Hallam Nuclear Power Station in Nebraska

One of the major atomic power stations now under construction in the United States is the Hallam Nuclear Power Facility being built by Atomics International, a division of North American Aviation, for the Consumers Public Power District of Nebraska. The plant will employ the sodium/graphite reactor, which offers the advantage of producing steam conditions comparable to modern steam power generation practice. The Hallam station will produce 75MW (electrical) using steam at 800 lb per square inch gauge and 825 deg. Fah. The reactor will use uranium dioxide as fuel, graphite as moderator, and sodium as the heat transfer fluid. The plant will operate with higher reactor coolant temperatures, higher fuel element surface temperatures and higher steam pressure and temperature than any other reactor under construction in the American Demonstration Power Reactor programme.

THE purpose of the Sodium Graphite Reactor (SGR) project in the Hallam Nuclear Power Facility near Lincoln, Nebraska, is " to demonstrate the economic and technical practicability of central station power, utilising a sodium graphite nuclear reactor, by operating the plant for the primary purpose of producing a maximum amount of electrical energy therefrom . . ." In so doing, it is intended to utilise and extend the knowledge obtained from the Sodium Reactor Experiment (SRE) which Atomics International built and is now operating for the U.S. Atomic Energy Commission. The current programme of work was initiated in November, 1957, and has two prime objectives. The first one was to carry out the preliminary engineering design so as to provide a complete set of criteria for the final design of the plant by September, 1958. The second objective was to carry out a prototype component development and test programme to provide data for the final design of all critical components. The schedule for the project provides for completion of construction of the nuclear facility in January, 1962, and for full power operation of the nuclear power plant in June, 1962. To meet its power commitments, the Consumers Public Power District plans to place in operation a coal-fired plant in the spring of 1961. The nuclear plant will supply steam to the turbine which initially will be installed with the coal-fired plant, and subsequently a second turbo-generator may be added for the conventional boiler. Included in the scope of the nuclear plant are the sodium/graphite reactor, the sodium heat transfer systems, the sodium steam generators, the overall power plant control system for nuclear operation, the nuclear fuel handling system, and various ancillaries. Fig. 1 shows the current progress of construction at the power station site, with the reactor core cavity liner being installed in the concrete vault.

The economics of the sodium/graphite reactor show that this design is potentially attractive for power plants with ratings from 100eMW up, where the relatively large investment costs associated with a physically large reactor and the shielding for a highly active coolant are compensated by high thermal efficiency and the ability to use modern and future steam equipment. A brief review of the properties of sodium and graphite explains the main characteristics of the reactor. The boiling point of sodium at atmospheric pressure is 1620 deg. Fah., which permits the exchange of heat from the reactor to a steam generator at high temperature and very low pressure. The low pressure eliminates hazard problems associated with releasable potential energy from the pressurisation of radioactive fluids and greatly simplifies the containment problems. The low pressure, combined with good heat transfer properties, permits a design with large temperature increase as heat is removed from the core and resulting low pumping power to the sodium systems. The sodium is chemically inert to fuel, graphite and structural materials in the reactor, thus avoiding the problems of release of chemical energy and of corrosion.

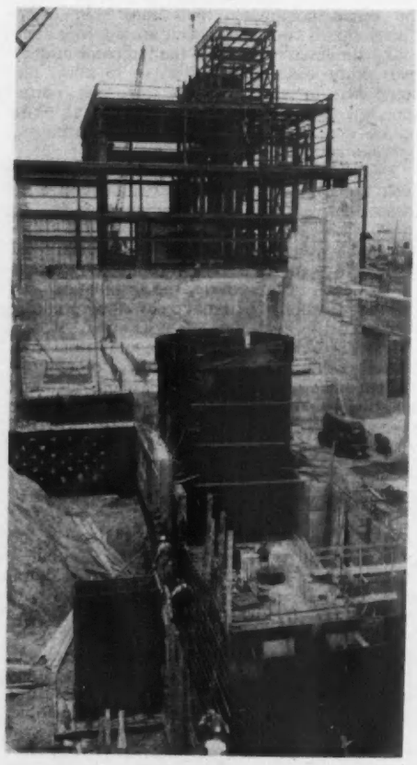


Fig. 1—Current construction progress of the Hallam atomic power station, with the reactor core cavity liner being installed

General Reactor Concept

Graphite is a good material to use with sodium coolant since it retains strength at extreme temperatures, is chemically compatible with sodium, is relatively inexpensive, is easy to handle, and meets normal moderator requirements. The sodium graphite system provides many interesting reactor concepts. Four particular designs were thoroughly studied at Atomics International. The through-tube reactor was one of the first studied as a variation from the Hanford production reactors. Fuel is suspended in vertical steel process tubes that separate the moderator from the fuel and coolant region. Sodium is brought to the process tubes by a pipe header system under the reactor and removed by a similar header system above the reactor. One version of this reactor provided a neutron shield between the core and the headers. This reactor provides good neutron economy through simple core construction. The principal problems encountered were graphite and process tube replacement in the event of a tube rupture, repairs in the header regions if no neutron shield is incorporated, and the design and analysis of the neutron shield if this is used.

The thimble tube reactor is another version of the use of process tubes in unclad graphite. In this core, a sodium header or manifold tank is suspended above the core on hanger rods from the shielding to supply sodium to the thimble tubes. Hollow-cylindrical fuel elements are hung from the tank so that the fuel element forms a return path for the coolant. Sodium discharges into a free surface pool in an insulated tray from which the sodium can be pumped to the heat transfer system. Again, neutron shield and non-neutron shield versions were considered. The advantages of the thimble concept are good neutron economy, accessibility of the tubes and a very high temperature reactor, since the main tank and tubes in the reactor see only low temperature sodium. Its problems are the protection of the graphite from sodium and sodium vapour, the development of the insulated tray and the design of the coolant system to cater for possible failures.

Two other concepts are tank-type reactors where sodium is pumped into a plenum formed by the core tank and a grid plate that supports the core. The sodium then flows upward through process tubes containing suspended fuel elements to discharge into a free surface pool over the core. In the calandria design, the graphite is separated from sodium by the calandria structure. Bellows are proposed for each tube to allow differential expansion between the tube and the main structure. This design provides good neutron economy coupled with a design concept that was tested in the SRE with the exception of the calandria structure. The main problem is considered to be the replacement of the tubes, or, alternately, the sealing of the tubes and protection of the graphite from the amount of sodium that would impair the moderation properties of the graphite.

The main feature of the fourth concept, which is that used for the present power station, is the use of multiple cans to separate graphite from sodium. Hexagonal steel-canned graphite prisms with corner scallops form the core region. Process tubes, which are attached to the grid

plate, separate high velocity coolant for the fuel elements from low velocity coolant that removes heat from the individual moderator cans. The SRE version of this concept places the fuel elements at the centre of the hexagonal prism. This core design provides segregation of graphite so that one failure in the graphite cladding will poison a small fraction of the core, provides relatively simple replacement of the moderator elements, and uses most of the SRE technology. The main disadvantage is the poorer neutron economy caused by the moderator cladding material and the moderator coolant sodium.

Plant Arrangement

An artist's impression of the installation is shown in Fig. 2. The station is a combination of a coal-fired plant which contains the turbo-generator and a nuclear plant which will provide steam for the turbine in the coal boiler plant. Each of these plants is in separate buildings. The building in the right-hand foreground houses the nuclear plant. The reactor and radioactive portions of the systems are above grade. The building is serviced with a bridge crane, in addition to the gantry crane used for fuel handling, and is of conventional industrial construction. Heat is removed from the reactor by a radioactive primary sodium system and is transferred to a non-radioactive secondary sodium system which serves the steam generators. The non-radioactive steam from the three steam generators is fed into a common steam header which serves the single turbo-generator in the coal boiler plant building. The sodium heat transfer system is operated at a pressure just sufficient to overcome pressure drops.

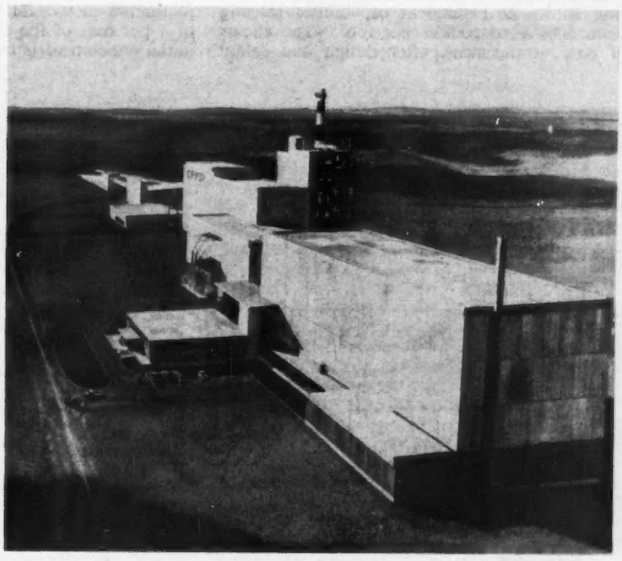


Fig. 2—Artist's impression of the combined coal-fired and nuclear-power plant at the Hallam site in Nebraska

A sodium service system is used to fill, drain and flush the reactor core tank and sodium heat transfer systems. The sodium service system also contains a purification system to remove oxides from the sodium to control corrosion rates and to preclude the impairment of mechanical and thermal performance of the equipment. A helium system is used to provide an inert gas within the reactor and nitrogen is used for the inert gas atmospheres in the shielded cells. There are also systems to remove, store and dispose of radioactive gases and radioactive liquid wastes. An organic cooling system provides auxiliary cooling to the concrete biological shielding of the reactor, certain sodium handling components and the atmosphere in the shielded radioactive cells. Cooling water for the organic cooling system and other services in the nuclear plant is supplied from cooling towers provided for the condensers in the turbo-generator plant.

TABLE I—*Hallam Nuclear Power Plant Characteristics*

Nominal rating	75eMW
Design net electrical power	80MW
Design gross electrical power	86MW
Reactor thermal power	254MW
Steam at turbine throttle :	
Pressure	800 lb per square inch gauge
Temperature	825 deg. Fah.
Steam flow to turbine	752,000 lb per hour
Condenser pressure	1·5in Hg absolute
Boiler feed-water temperature	304 deg. Fah.
Net plant heat rate	10,800 B.Th.U. per kWh
Net plant thermal efficiency	31·5 per cent

The fuel handling system consists of a fuel handling cask, fuel storage and washing cells, and all necessary equipment for receiving new fuel, refuelling the reactor and shipping spent fuel. A plant control system is provided which allows automatic operation over the range of 15 per cent to 100 per cent load, or manual operation at all loads. In addition, a plant protective system allows rapid detection of any abnormal condition in the reactor plant and automatically takes corrective action. This action includes alarm, one-circuit shutdown, setback, and scram. Table I summarises the power plant characteristics.

Reactor Design

The design of the present SGR scheme incorporates two innovations which differ from the SRE design. The fuel in the SGR is low enrichment (2·5 per cent U-235) uranium dioxide, and the graphite is canned in stainless steel sheet. The use of oxide fuel is an outgrowth of the lack of stability of metallic fuel at temperatures over 700 deg. Fah. Investigations to date indicate that burnups in excess of 10,000 MWD per ton are possible for the oxide, and that the cost of power will be less using the oxide. Although zirconium is used to clad the graphite in the SRE, the designers were uncertain of the life and long-term strength of zirconium or zirconium cladding. The substitution of zirconium alloy for stainless steel would permit a reduction of more than 1 per cent in the fuel enrichment, with appreciably lower fuel costs, and evaluation and testing of zirconium alloys are continuing.

The core of the reactor consists principally of vertically supported, stainless-steel-clad, hexagonal graphite prisms with corners scalloped to provide fuel and control locations. Process tubes, attached to a lower grid plate, are used to channel high velocity sodium from a lower plenum through the fuel elements at the fuel locations. Thimbles hanging from the top shield separate the control units from sodium at the control locations. The grid plate is plugged at these locations to avoid excessive cooling of the control units and moderator cans. Heat is removed from these units by a separate coolant stream that feeds into a small plenum formed by the grid plate and the bottom of each moderator element. Fig. 3 shows a section through the reactor core. The assembly of moderator elements, control units and fuel elements is contained in a steel tank and situated below the floor level of the reactor building. Radially outward from the core is a core tank liner, the core tank, the thermal shield, an outer tank, insulation, the cavity liner and a concrete foundation that serves as a neutron shield between the reactor and adjacent heat exchange cells. Below the core is a grid plate that supports the moderator and reflector elements and forms the coolant inlet plenum under the core, the tank bottom, a thermal shield, cylindrical steel supporting shells and foundation concrete. Above the core is an 8ft deep sodium pool, a helium blanket, reflective insulation and the top shield. Sodium is brought to the lower plenum by three double-walled pipes which enter the core cavity above the moderator elements, are brought down adjacent to the core tank and terminate at the tank bottom. Sodium is removed from the pool above the core through pipes which are attached about one pipe diameter above the moderator elements and then are offset upward so that the suction nozzles remain immersed in sodium if a leak develops in one of the heat exchange loops. The outer tank is built around the main tank to maintain the sodium level above the suction nozzles if a leak occurs in the core tank.

The present operating plans set the inlet sodium temperature at 607 deg. Fah. and the outlet sodium temperature at 945 deg. Fah. The pressure drop across the core is approximately 20 lb per square inch at a sodium velocity of 11·3ft per second in the fuel elements. The helium gas blanket will be maintained at a slight positive pressure of about ¼ lb per square inch gauge to prevent inward leakage of air. The current design limits all structural material to a maximum temperature of about 950 deg. Fah. Ultimate operation may increase these limits to about 1000 deg. Fah.

The present reactor design is the optimum case for a nineteen-rod uranium oxide fuel element. The fuel rods consist of ¼in diameter oxide pellets, enriched to 2·5 per cent, contained in 0·010in wall steel tubes. The core loading contains 243 of these rod cluster fuel elements and twenty-one dummy fuel elements. The total fuel weight is 56,000 lb of uranium oxide. The active core forms a cylinder, 14ft in diameter by 14ft high, and is surrounded by additional reflector cells about 2ft thick. An antimony-beryllium neutron source and approximately forty shim regulating and safety rods also occupy corner positions in moderator elements. Each fuel cluster or channel is individually orificed to facilitate the shaping of the channel outlet temperature profile of the reactor. Maintenance cells, accessible from the reactor operating room, will allow the changing of orifices as necessary. A fuel cluster is suspended from its shield plug by a hanger rod. The outlet sodium temperature for each fuel channel is measured by a thermocouple in the hanger rod, immediately above the fuel.

The moderator element is 14in across the flats of the hexagonal block and 18ft high. The

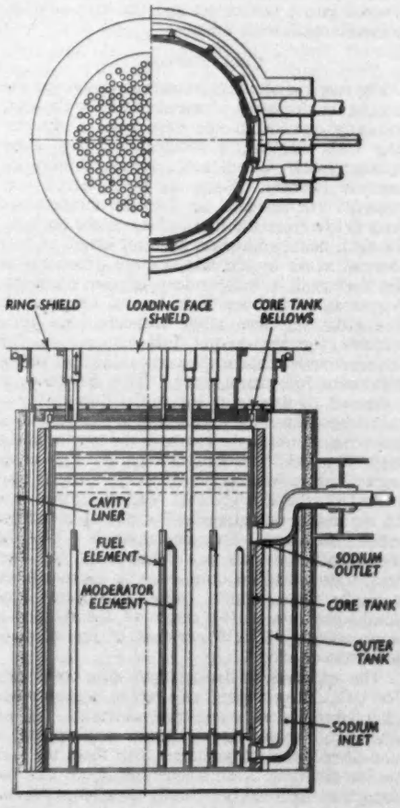


Fig. 3—Sectional views of the Hallam reactor cores

THE AMERICAN SCENE *(Continued)*

stainless steel cladding is 0·016in thick and all joints are fusion welded. There are 225 of the hexagonal elements in the reactor, including the reflector elements. The control and safety elements operate in thimbles extending into the core from the top shield. Heat generated in the poison material of the shim or regulating rods is conducted across a helium annulus within the thimble through the thimble wall and into the sodium flowing over the outside of the thimble. About half the rods are safety ones and are completely withdrawn from the active core during operation. These rods are released to fall by gravity into the core after a scram signal from the protective system. Development tests are in progress to determine the feasibility of a combined shim-safety unit, which would reduce the number of control units to approximately twenty.

The top shield and loading face of the reactor is a plug of high-density concrete, weighing about 400 tons, contained in a 24ft diameter, 6ft high shell of stainless steel. Supported on a roller bearing, the shield can be rotated when the reactor is shut down to give access to the moderator cans. This design is an extrapolation from that used on the SRE which is 16ft outside diameter. Ports and plugs penetrate the shield for each process channel in the core. Four ports, about 2ft wide and 4ft long, provide access to any moderator can in the core. Fuel handling for loading and unloading the reactor and for the transfer of irradiated fuel between the wash cells, is carried out with a shielded cask which is supported and moved with a gantry crane. The cask weighs about 140 tons and will traverse an area of the operating room, including the loading face, about 25ft by 100ft. The SGR fuel will be processed at the Oak Ridge works of the Union Carbide Nuclear Company in Tennessee. Based upon the experience with the SRE fuel cask and the present design, the annual plant down-time attributable to fuel changing is estimated to be four or five days. If replacement or investigation of moderator cans becomes necessary, internal parts of the fuel cask can be lowered into a service pit and the cask adapted to handle moderator units.

Core Design

The fuel elements under consideration for the present reactor are a nineteen-rod UO_2 element, currently considered the base case, a double-ring UO_2 element, a nineteen-rod low alloy uranium metal element, and a seven-rod thorium-uranium element. Since the metallic rod fuel elements are designed so that the temperature drop is low from the fuel surface to the coolant, the total heat production per unit length of fuel element is set by the temperature difference in the fuel and is independent of rod diameter. Assuming a 1200 deg. Fah. central temperature limitation for low alloy uranium, the only variable for the central fuel elements is the sodium temperature at the vertical location of the maximum fuel temperature. This difference is increased by arranging the radial flow distribution across the reactor, resulting in a low channel exit temperature in the centre of the reactor and a high channel exit temperature in the outer region. A maximum design temperature is also placed on the exit channel sodium temperature by the design of the moderator elements and the reactor structure. The general result is that the inner fuel channels are limited by the fuel temperature and the outer ones by the maximum coolant temperature. The maximum heat generation rate at the centre of the reactor is approximately 300kW per foot of fuel element for a Mo-U alloy.

The approach to the optimum core conditions for UO_2 differs slightly due to the heat removal characteristics of oxide fuel elements. If an oxide rod sealed in a helium atmosphere is considered, the temperature drop from the fuel to the cladding is no longer negligible and the total heat removal is partially dependent on rod diameter. Separate heat removal calculations are desirable for each rod diameter considered, as well as separate nuclear calculations. The results of these studies for the nineteen-rod UO_2 fuel elements show a heat generation rate of approximately 210kW per foot of fuel element in the centre of the reactor.

The other oxide concept currently under consideration is a double-ring fuel element. Since the heat removal capability of a thin annular ring at a fixed temperature drive varies inversely with ring thickness, the number of cases needed to establish an optimum configuration is greatly expanded over various rod designs. The double ring shows heat removal capabilities ranging from 300kW to 500kW per foot. The choice of core arrangement, after design and safety requirements are satisfied, is made by economic considerations, and an economic analysis is made for each fuel concept described above. A fuel cycle is first described and unit costs estimated for each step. For example, the fuel cycle for uranium rod metal fuel elements includes the purchase of UF_6, conversion of UF_6 to derbies and derbies to slugs with appropriate scrap recovery steps, the manufacture of fuel elements, storage at the reactor, burn-up in the reactor to an average 3000MWD per ton U, decay storage, chemical processing to nitrates, and the conversion of nitrates to plutonium metal and to UF_6. A lease charge of 4 per cent of the cost of the uranium at its initial enrichment is used for the total uranium

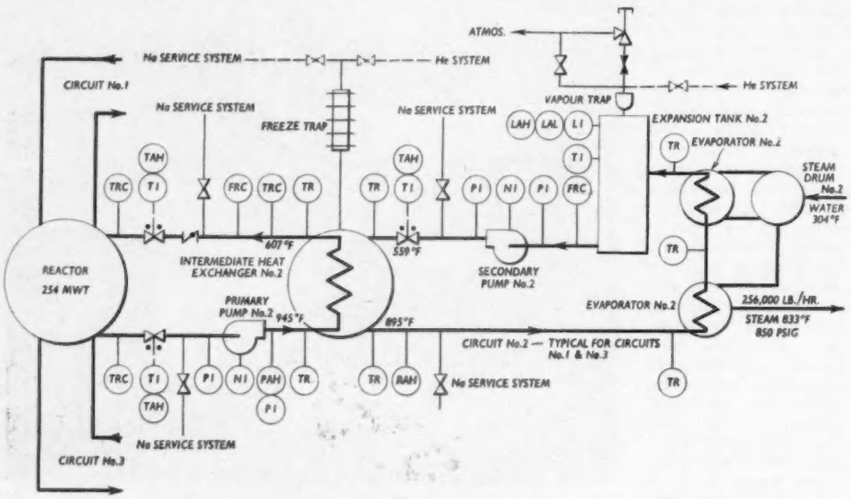
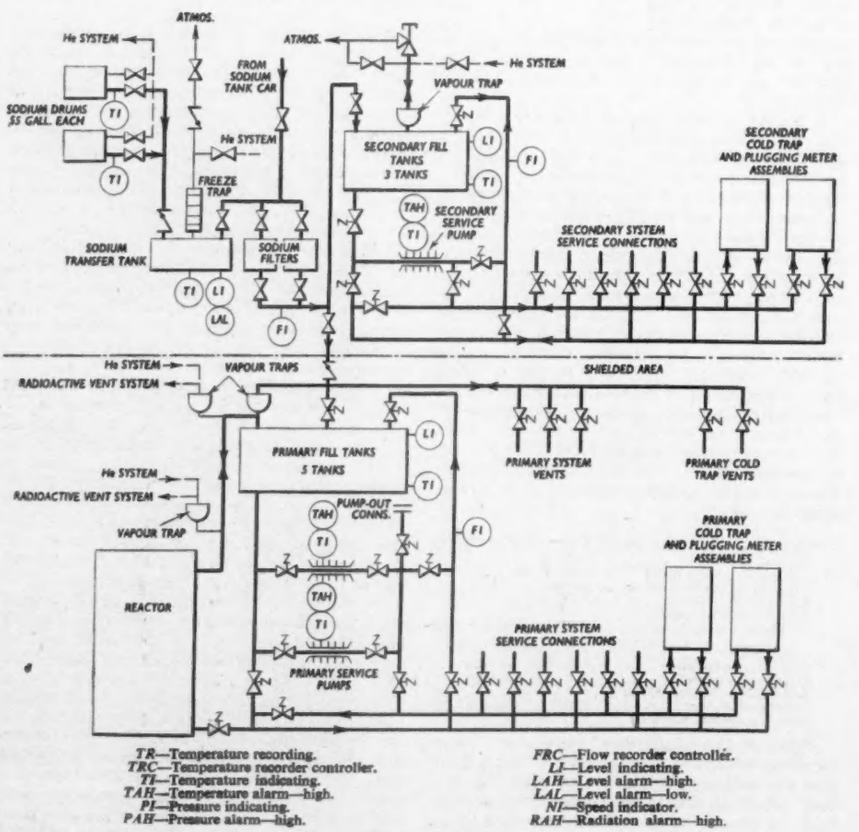


Fig. 4—Sodium heat transfer system



TR—Temperature recording.
TRC—Temperature recorder controller.
TI—Temperature indicating.
TAH—Temperature alarm—high.
PI—Pressure indicating.
PAH—Pressure alarm—high.
FRC—Flow recorder controller.
LI—Level indicating.
LAH—Level alarm—high.
LAL—Level alarm—low.
NI—Speed indicator.
RAH—Radiation alarm—high.

Fig. 5—Sodium service system

hold-up in the reactor and in the other steps of the fuel cycle. The time outside the reactor is estimated at 1·5 years. The average time in the reactor is one year for metal fuel and 3·5 years for oxide fuel. The cost of burn-up for a given case is found from the nuclear characteristics, the UF_6 costs published and an assumed credit for plutonium.

Sodium Systems

The sodium systems consist of the sodium heat transfer system and the sodium service systems. The sodium heat transfer system, consists of three independent circuits (one is illustrated in Fig. 4) with separate connection to the core tank. Each circuit handles one-third of the design full load sodium flow, transferring 85,000 thermal kilowatts, and consists of a radioactive primary loop and a non-radioactive secondary sodium loop. The primary sodium circuits transfer thermal energy from the reactor to intermediate heat exchangers, and the secondary circuits transfer thermal energy from the intermediate heat exchangers to the steam generators. Each intermediate heat exchanger is in a separately shielded cell, which facilitates isolating any single primary loop while the remaining two are operating.

There is a stop valve, flow control valve, and a non-return valve in each primary loop. The non-return valve vents sodium backflow in case of a primary pump failure. There is also a control valve in each secondary loop outside the shielded cells. The control valves are used only to control the sodium natural convection flow during the period of dissipating reactor decay heat. The expansion tanks in the secondary circuits have a regulated gas pressure to maintain the pressure of the secondary circuits higher than that of the primary circuits at the intermediate heat exchangers. This prevents radioactive contamination of the secondary circuits in the event a leak develops in an intermediate exchanger. All piping and components in contact with sodium are fabricated from 18-8 austenitic stainless steel, using welded joints throughout. All inaccessible sodium piping has instrumentation to detect sodium leaks. The sodium piping and equipment have electric heating to preheat the system before admitting sodium and also to keep the sodium in a fluid condition when the reactor is not in operation. All sodium piping and equipment are thermally insulated.

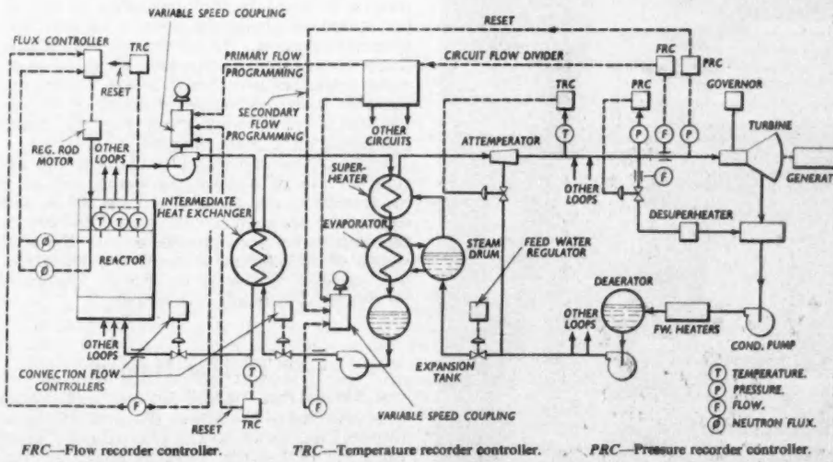
The pumps are centrifugal, rated at 7200 gallons per minute against a 150ft sodium head and driven by constant-speed a.c. motors through variable-speed electromagnetic couplings. Each of the three steam generator units consists of a boiler and steam drum, a superheater and a de-superheater. A third fluid monitoring system is included with duplex tubes in both the boiler and the superheater. The sodium service system is illustrated in Fig. 5 and provides the means to fill, drain, flush and purify the sodium in the reactor core tank and the sodium heat transfer systems. In the filling operation, sodium is received in drums or in a railway tank car. The sodium is melted, filtered and distributed to the primary or secondary fill tanks. The reactor and the primary loops can be drained collectively, or separately, by the primary service pump to the primary fill tanks. The secondary circuits are drained to the secondary fill tanks by inert gas pressure or the secondary service pump. Sodium flushing is used to reduce the activity of a primary loop before the heat exchanger cells can be entered. The loop to be flushed is drained to a primary fill tank and then filled with fresh sodium from another of the primary fill tanks. Cold traps are used to remove oxides from the sodium, and plugging meters are used to measure the oxygen content of the sodium. The cold traps are of the circulating type in which the sodium is cooled with tetralin to permit the deposit of the oxides in the traps. The primary system and the secondary system each have their own cold traps. The cold traps can be used to purify the sodium in the fill tanks, or in the heat transfer system.

Auxiliary Systems

The reactor auxiliary systems include the organic cooling system, inert gas systems, the radioactive vent system and the radioactive liquid waste system. The organic cooling system provides cooling for all components in the reactor plant that are to be maintained at controlled temperatures. Because the system serves areas where possible leakage might result in interaction with sodium, a coolant such as tetralin, which is relatively inert to sodium, is used. This system is divided into two circuits. One circuit is composed of items which require uninterrupted coolant. The pumps in this circuit are also on the emergency power system to ensure continuous operation under all conditions. The second circuit is composed of items which can stand interrupted service between the time there might be a power failure and the start-up of diesel-generated power.

The inert gas systems consist of a helium system and a nitrogen system. The helium system is used to establish an inert gas atmosphere within all piping vessels and equipment containing sodium. The nitrogen system is used to establish an inert gas atmosphere in the shielded areas where radioactive sodium might come in contact with the atmosphere in the event of equipment rupture. Individually pressure-controlled stations and relief valves maintain the gas pressures within the desirable limits for each user. The exhaust from relief valves on systems which may be radioactive are connected to the radioactive vent system.

The radioactive vent system collects all gas that is radioactive and delivers it to shielded storage tanks. The radioactive liquid waste system collects, stores and disposes of the radioactive waste resulting from the cleaning of fuel elements or from decontamination operations in the maintenance cells. The fuel cleaning operation consists essentially of washing the spent fuel element with water, removing the hydrogen gas evolved into a radioactive vent system, and draining the waste water and sodium hydroxide formed to decay tanks where the liquid is held until the activity is reduced for final disposal.



FRC—Flow recorder controller. *TRC*—Temperature recorder controller. *PRC*—Pressure recorder controller.

Fig. 6—SGR plant control system

Reactor Instrumentation

The nuclear instrumentation is divided into nine channels: two count rate, two log *n*, and five power level channels. These instruments provide adequate flux measurements from source level to approximately 150 per cent of full power. In addition to providing reactor control signals, the nuclear instrumentation provides signals to the plant protective system. The neutron detectors are placed in the instrumentation thimbles which are close to the reactor core. The count rate and log *n* channels are used for reactor start-up. Two power level channels are used for automatic power regulation. The remaining three power level channels are used in the protective system through coincident circuits. The flux signals from all of the channels are indicated in the control room.

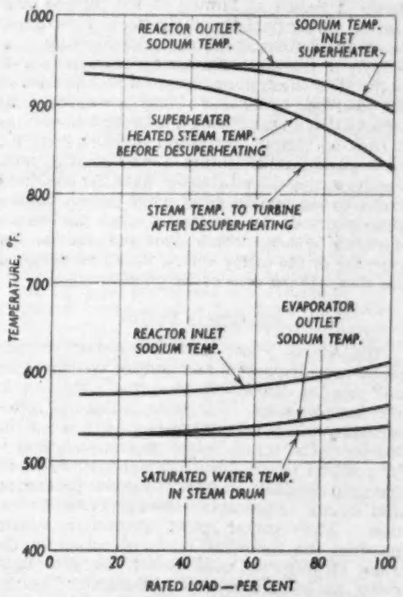


Fig. 7—SGR temperature programme at steady-state load conditions

Thermocouples are used to measure fuel channel sodium exit temperatures. These temperature signals are used for normal reactor control as well as for actuating the reactor plant protective system. All fuel channel thermocouples are monitored. Additional thermocouples are situated throughout the reactor vessel and biological shielding; these temperatures are monitored by means of a selector and indicator.

The plant control system, shown in Fig. 6, is intended to provide load-following automatic operation over the range of 15 to 100 per cent load, or manual operation at all loads. The control system is designed to provide operation as flexible as that of a conventional steam power plant. The temperature programme at steady state load conditions is shown in Fig. 7. It is noted that the reactor inlet and outlet sodium temperatures are held fairly constant, thus minimising transient stresses in the reactor. Also, the steam temperature and pressure to the turbine are held constant. The saturated water temperature in the steam drum decreases slightly on partial load to compensate for the reduced steam pressure drop, so that the steam pressure at the turbine will be constant at all loads. The secondary sodium temperatures, feed-water temperature and the steam temperature at the superheater outlet are allowed to vary.

The regulating elements and controlled variables are as in Table II.

The flow signal from the steam line is an anticipating signal which will cause the sodium flow and reactor power level to respond rapidly to the turbine load demand. In Fig. 6 the steam

THE AMERICAN SCENE (Continued)

TABLE II—*Regulating Elements and Controlled Variables*

Regulating elements	Programme variable	Reset variable
Control rod position	Reactor power	Sodium outlet temperature
Secondary sodium pump speed	Secondary sodium flow	Steam pressure at turbine
Primary sodium pump speed	Primary sodium flow	Reactor inlet temperature
Feed-water valve	Feed-water flow	Water level in steam drum
Attemperator (desuperheater) valve	Water to attemperator	Steam temperature to turbine
Turbine governor	Steam flow to turbine	Plant output

dump is shown as flowing to the turbine condenser. In the final design, the steam dump could be to the turbine condenser or a separate condenser, to the atmosphere, or a combination of both. The steam dump system would be used in the following operations : reactor start-up ; to remove decay heat during a long shut-down ; as a back-up method for steam pressure control ; as a partial relief during a turbine trip, and, finally, during a load transfer from the coal-fired boiler to the nuclear plant while power is being generated. It is anticipated that the steam dumping system, which does not include the capacity of the safety valves, would be designed for about 25 per cent of the plant rating.

PROTECTIVE SYSTEM

The reactor plant protective system consists of an instrumentation and control system which will rapidly detect any abnormal condition in the reactor plant and, when necessary, automatically reduce reactor power level or scram the reactor. The reactor plant protective system is in addition to the plant control system, which serves to regulate automatically power generation and reactor temperatures during normal operation. The reactor plant protective system provides the following kinds of action in the event of abnormal conditions : alarm ; shut-down one sodium heat transfer circuit ; reactor setback ; reactor scram. By a combination of these various kinds of protective action, reliability is ensured while maintaining the maximum practicable safety level.

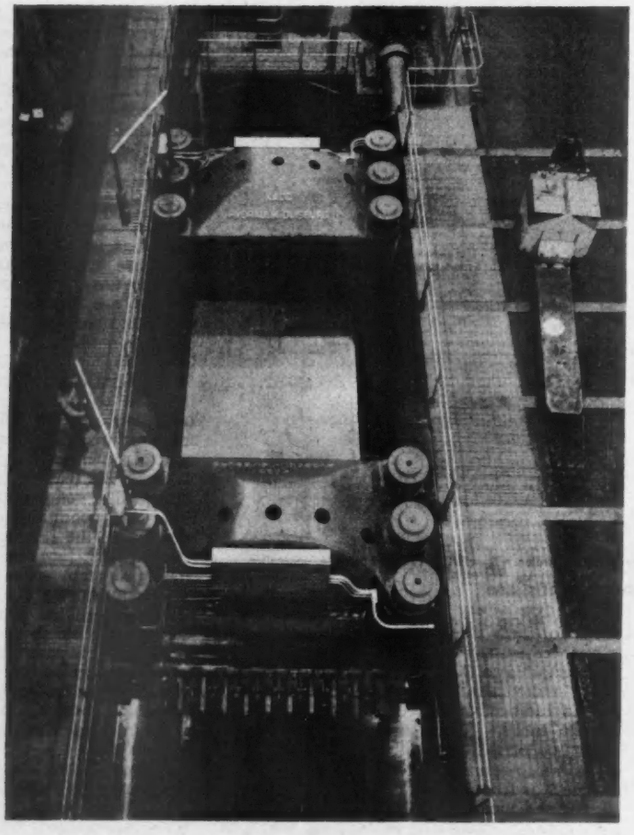
The reactor and the sodium systems operate under low pressure. High pressure is found only in the steam and feed-water systems. The reactor and its associated radioactive components are situated in shielded areas. Containment of radioactive fluids is provided by welded steel containers and piping, steel liners on the concrete shielding, and sealed joints on the removable shielding. An inert gas atmosphere is used in all areas containing primary system piping and components. Within the reactor there is no releasable potential energy from pressurisation or chemical reaction.

An automatic plant control system provides for safe normal operation of the reactor power plant. A plant protective system provides additional automatic control of the reactor systems for safety against failure or improper operation of any component. The protective system is designed for reliability, with reactor [scrams reduced to a minimum and in general supplemented by means which provide merely a power reduction or a shorter shut-down time.

The regulating and shim rods, which serve to control reactor power level during normal operation, have a rate which is limited to ensure that excessive reactivity cannot be inserted by erroneous action. Safety rods which fall by gravity into the reactor core provide scramming action in the event that other protective system action cannot adequately assure plant safety. The strong negative prompt-temperature-coefficient-of-reactivity provides reactivity control over upsuiges in fuel temperature. During a plant shut-down one or more of the three independent sodium heat transfer circuits may be used for cooling the reactor to remove stored and afterglow heat. Natural convection is more than adequate to transfer the afterglow heat after full power operation.

30,000,000 lb Aluminium Plate Stretcher

AN extremely large hydraulic plate stretching machine recently was put into operation at the Ravenswood Works of the Kaiser Aluminum and Chemical Corporation in West Virginia. The machine has been installed in a concrete pit 120ft long, 32ft wide and 15ft deep and possesses a pulling force capacity of 30,000,000 lb, or nearly twice that of the largest stretcher previously in operation in the American metals industry. It can handle aluminium alloy plate up to 6in thick, 13ft 4in wide and 60ft long, within an overall cross-sectional area limit of 640 square inches. The main purpose of the stretcher is to handle the heat-treated alloys and welding alloys that are now gaining increasing use in a wide variety of industrial and structural applications.



30,000,000 lb hydraulic plate stretcher at Ravenswood works, Kaiser Aluminum

The weldable aluminium alloys introduced within the past few years are finding growing use in marine construction, in the chemical process and petroleum industries for tanks and process equipment, in railway equipment and as ballistic armour plate in the lightweight vehicles for the U.S. Army. One of the more rapidly growing fields of applications for these alloys is in the fabrication of vessels for processing, storage and transportation of liquid methane, oxygen, nitrogen and hydrogen.

The production of heavy stretched plate was pioneered by Kaiser Aluminum when it installed in 1952 a stretcher with a capacity of 5,000,000 lb at its Trentwood rolling mill. Although at the time it was the largest stretcher in existence, its capacity was later doubled as industrial demand increased for stretched plate in larger dimensions. When planning commenced in 1954 for the sheet and plate rolling facilities to be installed at the new Ravenswood Works, the decision was made to include a stretcher of much higher capacity to produce still larger plate.

To handle the tremendous forces involved in a 30,000,000 lb stretcher, a number of unusual ideas were incorporated in the design of the stretcher which was undertaken by the Advanced Engineering Design Section of the firm at Oakland, California. The machine (illustrated here) is supported, without a guiding frame, on tracks, and no effort is made to hold it in a rigidly fixed alignment. The individual heads are supported on each side by eight railway-type car wheels on a double track. The hydraulic system has been designed to keep the two sides of the machine parallel and completely independent of the load in the gripping jaws. The gripping heads are of an unconventional design. There is a top and bottom head, each weighing 132 tons, held together by six forged tie bolts, 15in in diameter and 15ft long. The stretching force is provided by the application of 6000 lb per square inch hydraulic pressure on two 56in diameter cylinders. To absorb the tremendous forces that would be involved should a plate break while being stretched at full power, the stretcher jaw mechanism includes a hydro-pneumatic system very much like the recoil equipment on a heavy cannon.

Some of the individual components of the stretcher are of massive size—each half of a head, made of cast steel, weighs 264,000 lb, and each of the two solid columns weighs 145,000 lb. However, it has been possible to keep the total weight of the machine to less than 3,000,000 lb. The stretcher was built for Kaiser Aluminum by Hydraulik G.m.b.H. of Duisburg.

Gas Turbine Haulage

A "WHIRLFIRE" GMT-305 gas turbine has been delivered by the Allison Division of General Motors Corporation to The International Nickel Company of Canada, Ltd., to power a truck hauling ore from an open pit in the Sudbury District of Ontario. The engine is rated at 225 h.p. and is distinguished by a rotary regenerator with a cylindrical matrix : it was illustrated on page 995, December 26, 1958. It is expected that a high proportion of operation will be at full power, since the truck will be making a 2 mile climb on a winding road with a gradient of about 1 in 12 loaded with 32 tons of ore. The gas turbine is attractive in this case particularly because of the climate which is frequently sub-zero. One GMT-305 has been started after extended cold soaking at −45 deg. Fah. and, in about thirty seconds, from −65 deg. Fah.

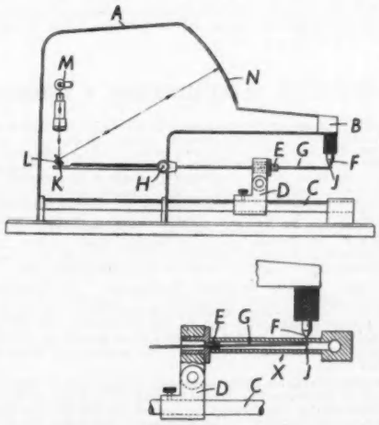
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

MEASURING EQUIPMENT

826,695. January 24, 1958.—LINEAR DIMENSION MEASURING OR CHECKING APPARATUS, Rolls-Royce, Ltd., Nightingale Road, Derby. (*Inventor : Frederick Brian Oddie.*)

This invention relates to apparatus for measuring the thickness of the wall of a bore, and is more particularly applicable to measuring the wall thickness of cooling fluid holes in gas turbine blades. Referring to the drawing the apparatus consists of a base on which is mounted a casing *A* having an extended arm *B*. Below and in line with the arm *B* is a slide *C* supported on the base by three pillars and carrying a saddle *D* which may be moved between the two right-hand pillars and clamped in position. The saddle carries a locating member *E* which is adapted to receive in spigot fashion one end of a bore, the thickness of the wall around which is to be determined. Secured to the arm *B* is an electromagnet having a fixed armature *F*, the tip of which acts as a support for the other end of the wall. The locating member *E* contains a passageway through which passes a rod *G* pivoted at *H* in conical pivots secured to fixed structure. At its right-hand end the rod terminates in a ball *J*, in close proximity to the tip of the armature. The left-hand end of the rod *G* actuates through a pin *K* a pivoted mirror *L*. A light source is illustrated at *M*



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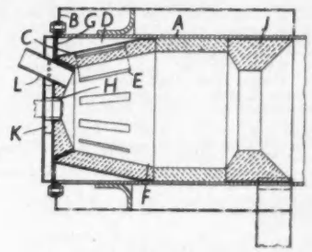
and a ray of light is produced by means of a lens-graticule combination to impinge on mirror and be reflected on to a translucent scale *N*. The deflection of the rod *G* is thus magnified by a ratio of, say, sixty at the translucent scale. Referring now to the lower drawing which shows the right-hand end of the apparatus to a larger scale, *X* indicates generally a section through a gas turbine blade, the wall thickness of which is to be measured. The tip of the hole in the blade is mounted on the spigot member *E* and the blade is held in contact with the tip of the electromagnet *F*. The electromagnet is switched on and the feeler *J* is attracted towards the tip *F* until it comes into contact with the inner surface of the wall, moving the lever *G* about its pivot and tilting the mirror so that the light ray is deflected along the scale *N*, this reading indicating the wall thickness. The blade may then be rotated about the axis of the hole and any variation in wall thickness will appear as a deflection of the light ray on the screen. The saddle may be adjusted in its position on tube *C* to bring any portion of the blade wall between the feeler and electromagnet. —*January* 20, 1960.

COMBUSTION CHAMBERS

826,692. January 9, 1958.—FUEL COMBUSTION CHAMBERS, Cradley Boiler Company, Ltd., Wood Lane, Cradley Heath, Stafford, and Rudling (Liquid Fuel) Burners, Ltd., 804-808, Green Lanes, Winchmore Hill, London, N.21. (*Inventors : Frank Davies, George William Bromley and Gordon James Evans.*)

This combustion chamber comprises a cylindrical sleeve *A* concentrically mounted in a smoke box of the boiler with one end against the end wall *B* of the box. Within the sleeve and with its narrower end towards the end wall is a tapering member *C*, so that there is formed between the member and the sleeve a tapering annular chamber *D* to which preheated air under pressure can be admitted. In the tapering member are a number of angular slots to the sides of which are secured plates which define between them a secondary air inlet *E*. These plates are inclined, and the spaces between them are filled with refractory material, so that the secondary air inlets extend tangentially into a mixing zone *F* of the combustion chamber. To the end wall *B* of the smoke box is secured a disc *G* forming the end of the combustion chamber. This disc is lined with refractory material, which has a dished internal surface of shallow conical form. At the centre of the disc is mounted the nozzle *H* of a burner, the arrangement being such that an annular primary air



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inlet is formed between the burner nozzle and the edges of the aperture. On the outside of the disc is an air chest which, through a ring of apertures, is supplied with preheated air under pressure from the same source as the chamber *D*. Beyond the mixing zone the sleeve has a refractory lined cylindrical inner surface which defines a combustion zone. Thus the interior surface of the parts of the combustion chamber so far described are of substantially parabolic form in longitudinal section. Furthermore, a refractory lining *J* for the sleeve at the outlet end of the combustion chamber is shaped to define a restricted throat opening into a divergent outlet. In the air chest are spaced and curved vanes *K* for causing a swirl in the primary air entering the mixing zone of the combustion chamber through inlet *H*, and the tangential direction of the secondary air inlets *E* is designed to cause a swirling effect in the same direction. Extending through the air chest and disc are tubes *L* forming respectively a sight hole, and a duct for the electrodes of an electrical flame ignition means. To control the admission of air to the annular chamber *D* a balanced flap valve is associated with a tangential air inlet formed in the wall of the sleeve *A*. By the present invention it is possible to obtain a relatively high rate of combustion and heat release per unit area of combustion space. Furthermore, it is possible to maintain the combustion products at a substantially uniform temperature and composition, and to adjust the carbon monoxide and/or carbon dioxide content to any specific duty.—*January* 20, 1960.

MACHINE TOOLS

826,427. March 25, 1957.—TEMPLATE DEVICES FOR COPYING LATHES, Maxnovo Meccanica di Precisione S.p.A., Via Guiseppe Negri 2-Novara, Italy.

This invention relates to an indexible multiple template holder for copying lathes and in particular to a device for preselecting the templates to be used in a specific automatic cycle of the lathe. There is provided an indexible multiple template holder comprising a rotatable carrier adapted to support a number of templates. Elements corresponding in number to the templates rotate with the carrier and means operable by the tool carriage of the lathe cause indexing of the elements and the template carrier. Means actuated by the elements limit the number of indexing steps of the template carrier between operating traverses of the tool. It is usually necessary to vary the speed of rotation of the workpiece, movements of the tool-holder slide and the controls for various working traverses of the tool. For this purpose there may be provided a control member rotatable with the template carrier and provided with studs adapted to actuate electric switches for synchronously controlling variations in the automatic cycle of the lathe.—*January* 6, 1960.

ELECTRIC LIGHTING

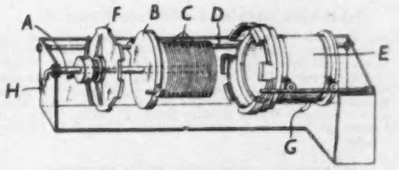
826,772. January 10, 1957.—LOW-PRESSURE MERCURY VAPOUR FLUORESCENT ELECTRIC DISCHARGE LAMPS, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. (*Inventors : Jack Lofts and Edward Ernest Miles.*)

To assist their starting, fluorescent lamps are often provided on their outer surface with a thin conducting strip extending between the electrodes. Various methods of forming such conducting strips have been proposed, and so also have methods of connecting the strips to the lamp caps, but none of these prior proposals has proved satisfactory in mass production of the lamps for various reasons. The main object of the invention is to provide a cheap and efficient construction for the strips and their connections to the lamp caps that can readily be realised during the mass production of the lamps by modern methods and machinery. The specification describes a lamp provided on the outer surface of its envelope with a conducting strip in the form of particles of silver embedded in a vitreous medium bonded to the envelope. This strip extends along the region between the electrodes and at least at one end of the envelope extends under or close to a metal cap attached to the envelope, to which it is conductively connected by a small quantity of silver powder embedded in a resinous medium bonded to the strip and to the cap. The quantity of silver embedded in these media is preferably such that the electrical resistance of the conducting strip is less than 100 ohms per foot, and such that the electrical resistance of the connection between the strip and cap is less than 25 ohms. Preferably the strip is connected to a metal cap at each end of the envelope by the silver-impregnated resinous bonding medium.—*January* 20, 1960.

FILTERS

826,690. December 31, 1956.—PRESSURE VESSEL FOR A FILTER LEAF ASSEMBLY, Whitco Equipment, Ltd., 696, Yonge Street, Toronto, York, Ontario, Canada. (*Inventor : Horace Byron Whitmore.*)

The principal object of this invention is to provide a pressure vessel for a leaf-type filter of simple construction which can be readily dismantled and re-assembled to greatly facilitate servicing, cleaning and maintenance. With reference to the drawings,



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in a housing there is a tube *A* which is supported as a cantilever arm having mounted on it a filter leaf assembly comprising a fixed head *B* and filter leaves *C* separated by spacers. Each of the filter leaves comprises a relatively coarse screen covered on opposite sides by a fine mesh screen or cloth. A series of orifices through the wall of the tube *A* provide communication between the interior of the filter leaves and tube bore. Slidably mounted on the housing rods *D* is a casing or shell *E* having at its open end a locking head with lugs recessed on their inner faces. Slidably mounted on the tube *A* is a capstan which has threaded thereon a disc *F* having spaced lug projections corresponding to the lugs of the locking head of the shell. The capstan and disc are adapted to be slid along the tube so that its lugs enter the notches in the casing *E* and on the disc being turned its lugs mate with the recesses at the rear of the casing lugs. Upon turning the capstan to advance it inwardly its inner end will engage the fixed head *B* of the filter leaf assembly and will draw the casing *E* along the tracks into clamping engagement with the filter leaf head. In operation the material to be filtered is introduced into the shell *E* through an inlet *G* when the shell is closed and locked with the fixed head. The liquid portion of the material passes through the filter screen to the interior of the tube whence it is discharged through the outlet *H*. The removal of the filter cake may be readily accomplished by cutting off the flow of material and opening the filter by backing up the capstan, turning disc *F* and sliding the shell clear on the tracks.—*January* 20, 1960.

Forthcoming Engagements

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ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Feb. 19.—STOKE AND CREWE BRANCH : Grand Hotel, Hanley, Films Night, 7.30 p.m.
Tues., Feb. 23.—EAST KENT BRANCH : County Hotel, Canterbury, "Nuclear Energy," B. H. Stonehouse, 8 p.m.
Thurs., Feb. 25.—BRIGHTON, HOVE AND DISTRICT BRANCH : New Imperial Hotel, First Avenue, Hove, "Stage Lighting in Schools and Small Halls," F. E. Brown, 7.30 p.m. ★ OXFORD AND DISTRICTS BRANCH : Reactor School, A.E.R.E., Harwell, "Electric Motor Control Gear" R. F. Mathieson, 5.45 p.m. ★ SOUTHAMPTON BRANCH : Polygon Hotel, Southampton, "A.C. Motor Control Gear," S. H. Harding, 8 p.m. ★ SOUTH LONDON BRANCH : Greyhound Hotel, High Street, Croydon, Surrey, "Control Aspects of Nuclear Power Stations," R. D. Trotter, 8 p.m.
Fri., Feb. 26.—COVENTRY AND DISTRICT BRANCH : E.M.E.B. Sports and Social Club, Merrick Lodge, Sandy Lane, Coventry, Films, "Kermesse Fantastique" and "Essential Rays," 7.45 p.m.

BRITISH COMPUTER SOCIETY

Thurs., Feb. 25.—SOUTH WALES AND MONMOUTHSHIRE BRANCH : Small Shandon Lecture Theatre, University College, Cardiff, "Basic Principles of Programming," Part 2, R. J. Ord-Smith, 6.30 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Feb. 24.—MEDICAL ELECTRONICS GROUP : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "The Unification of Electronic Clinical Instruments," F. D. Scott, 6.30 p.m. ★ SOUTH WESTERN SECTION : School of Management Studies, Unity Street, Bristol, "Industrial Magnetic Recording and Playing Machine Design," J. Elliot, 7 p.m.

BRITISH INTERPLANETARY SOCIETY

Tues., Feb. 23.—Royal Society of Arts, John Adam Street, London, W.C.2, Joint meeting with the Institution of Plant Engineers, "Some Problems Encountered in the Design of Large Rocket Test Beds," R. H. B. Forster, and L. Breen, 7 p.m.

CEMENT AND CONCRETE ASSOCIATION

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Thurs., Feb. 25.—College of Technology, Anglesea Road, Portsmouth, "Thermal Insulation of Buildings," R. R. Houston, 7.15 p.m.
Fri., Feb. 26.—Medway College of Technology, Maidstone Road, Chatham, "Practical Formwork, Design and Construction for Concrete," J. G. Richardson, 7.15 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Tues., Feb. 23.—NORTH WESTERN REGION : Engineers' Club, Albert Square, Manchester, "Refractories for Kilns and Furnaces," N. W. Hinchliffe, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Feb. 22.—BIRMINGHAM CENTRE : Regent House, St. Philip's Place, Colmore Row, Birmingham, Annual General Meeting and Symposium, 6 p.m. ★ LEEDS CENTRE : British Lighting Council, 24, Aire Street, Leeds, 1, "The Design and Manufacture of Neon Signs," A. Urquhart, 6.15 p.m. ★ LEICESTER CENTRE : Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester, "Practical Aspects of Neon and other Luminous Signs," T. Coates, 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Feb. 24.—LONDON BRANCH : Constitutional Club, Northumberland Avenue, London, W.C.2, "Modern British Bathmaking Practice," G. R. Webster, 7.30 p.m.

INSTITUTE OF FUEL

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INSTITUTE OF METAL FINISHING

Wed., Feb. 24.—ORGANIC FINISHING GROUP : Engineering Centre, Stephenson Place, Birmingham, 2, "Cold Airless Spraying" W. B. Noon, 6.30 p.m.

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Thurs. Feb. 25.—LONDON BRANCH : 61, New Cavendish Street, London, W.1, "Atomic Power for Marine Applications," G. Fawn, 6 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

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INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 23.—TRAFFIC ENGINEERING STUDY GROUP : Great George Street, Westminster, London, S.W.1, Discussion on "Junction Design on Motorways," introduced by J. G. Smith, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Sat., Feb. 20.—LONDON GRADUATE AND STUDENT SECTION : Visit to Houses of Parliament (Plant Room and Technical Services), 10.30 a.m.
Mon., Feb. 22.—INFORMAL MEETING : Savoy Place, London, W.C.2, Discussion on "Are We Making the Best Use of Research Resources ?" opened by L. Rotherham, 5.30 p.m. ★ EAST ANGLIAN SUB-CENTRE : Technical College, Cambridge, Discussion on "The Provision of Adequate Electrical Installations in Buildings," 6.30 p.m. ★ MERSEY AND NORTH WALES CENTRE : Town Hall, Chester, Joint meeting with the North-Western Centre ; "A Frequency-Response Method for the Predetermination of Synchronous-Machine Stability," A. S. Aldred and G. Shackshaft, 6.30 p.m. ★ NORTH-EASTERN CENTRE : Neville Hall, Westgate Road, Newcastle upon Tyne, "The Characteristics and Protection of Semiconductor Rectifiers," D. B. Corbyn and N. L. Potter, 6.15 p.m. ★ SOUTH MIDLAND ELECTRONICS AND MEASUREMENT GROUP : James Watt Memorial Institute, Birmingham, "Silicone Transistors —Their Manufacture and Fields of Application," J. T. Kendall, 6 p.m. ★ WESTERN UTILIZATION GROUP : South Wales Institute of Engineers, Cardiff, "The Spark Machining of Hard Metals," G. H. Townend, 6 p.m.
Tues., Feb. 23.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Discussion on "Courses for Electrical Technicians," opened by M. W. Humphrey Davies, 6 p.m. ★ NORTH-WESTERN SUPPLY GROUP : Engineers' Club, Albert Square, Manchester, "The Application of Low-Pressure Resins to Some High-Voltage Switchgear Designs," T. R. Manley, K. Rothwell, and W. Gray, 6.15 p.m. ★ NORTHERN IRELAND CENTRE : David Keir Building, Queen's University, Stranmillis Road, Belfast, "The Linear Induction Motor," E. R. Laithwaite, 6.30 p.m. ★ SOUTH-WEST SCOTLAND SUB-CENTRE : Royal College of Science and Technology, Glasgow, "Ultra-Sound Image Camera," C. N. Smyth and J. Sayers, 6 p.m.
Wed., Feb. 24.—ELECTRONICS AND COMMUNICATIONS SECTION : Savoy Place, London, W.C.2, "Applications of Microwaves," A. L. Cullen, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION : Visit to Post Office, Research Station, Dollis Hill, London, N.W.2, 2.15 p.m. ★ SOUTH-EAST SCOTLAND SUB-CENTRE : Carlton Hotel, North Bridge, Edinburgh, "Ultra-Sound Image Camera," C. M. Smith, and J. Sayers, 7 p.m. ★ SOUTHERN CENTRE : Central Telephone Exchange, Park Road, Portsmouth, "Development of the Formulae of Electro-Magnetism in the M.K.S. System," P. Vigoureux, 6.30 p.m.
Thurs., Feb. 25.—NORTH MIDLAND CENTRE : Y.E.B. Offices, Ferrensway, Hull, "Subscriber Trunk Dialling," D. A. Barron, 6.30 p.m. ★ WESTERN UTILIZATION GROUP : Demonstration Theatre, S.W.E.B., Kingsway, Swansea, "The Organisation of Industrial Electrical Maintenance," S. R. Phelps, 6 p.m.
Mon., Feb. 29.—NORTH-EASTERN MEASUREMENT AND ELECTRONICS GROUP : Rutherford College of Technology, Newcastle upon Tyne, "Radio Aspects of the International Geophysical Year," R. L. Smith-Rose, 6.15 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Fri., Feb. 26.—Robert Gordon's Technical College, Aberdeen, "Vibration Problems in Marine Machinery and their Solution," W. McLaughlin, 7.45 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Feb. 19.—NORTH-EAST BRANCH : Municipal Buildings, Middlesbrough, "The Design and Installation of Corrugated Metal Structures," P. R. S. Holmstrom, 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 19.—YORKSHIRE GRADUATES' SECTION : Royal Station Hotel, Hull, "What Do You Know About Patents ?" T. A. Hulse, 7 p.m.
Mon., Feb. 22.—EDUCATION GROUP DISCUSSION : 1, Birdcage Walk, Westminster, London, S.W.1, "The Place of Management Studies in the Training of an Engineer," 6 p.m.
Tues., Feb. 23.—LUBRICATION GROUP DISCUSSION : 1, Birdcage Walk, Westminster, London, S.W.1, "Water Lubrication," 6 p.m. ★ WESTERN BRANCH : Engineering Laboratories, The University, Bristol, "The Gas Turbine Engine in Civil Aviation," S. G. Hooker, 6.30 p.m. ★ BIRMINGHAM AUTOMOBILE DIVISION : James Watt Memorial Institute, Great Charles Street, Birmingham, "The Mechanical Design and Performance of the Petrol Engine," W. V. Appleby, 6.30 p.m. SCOTTISH GRADUATES' SECTION : Visit to Hoover (Electric Motors), Ltd., Cambuslang, Lanarkshire, 7 p.m.
Wed., Feb. 24.—ORDINARY MEETING IN CONJUNCTION WITH THE STEAM GROUP : 1, Birdcage Walk, Westminster, London, S.W.1, "Wetness in Steam Cycles," B. Wood, 6 p.m. ★ YORKSHIRE BRANCH : Royal Station Hotel, Hull, "Marine Refrigeration," H. R. Howells, 7.30 p.m. ★ EASTERN GRADUATES' SECTION : Visit to W. H. A. Robertson, Bedford, 7.30 p.m. ★ SOUTHERN GRADUATES' SECTION : Recreational Society Pavilion, Aldermaston, "Comparative Properties of Rubber," E. Gunn, 3 p.m.
Thurs., Feb. 25.—N.W. BRANCH : Engineers' Club, Albert Square, Manchester, "A Review of Nuclear Reactor Developments," R. V. Moore, 6.45 p.m. ★ WESTERN AUTOMOBILE DIVISION : Royal Hotel, Bristol, "Automobile Steering Suspension and Tyres," D. Bastow, 6.45 p.m. ★ E. MIDLANDS GRADUATES' SECTION : College of Further Education, Loughborough, "Electronics for the Mechanical Engineer," M. J. Hamblin, 7.15 p.m. ★ LONDON GRADUATES' SECTION : 1, Birdcage Walk, Westminster, London, S.W.1, "Some Aspects of Aircraft Flight and Crash Protection with Emphasis on the Power Plant," F. A. A. Palmer, 6.30 p.m.
Sat., Feb. 27.—E. MIDLANDS GRADUATES' SECTION : Visit to British Transport Commission Carriage and Wagon Works, Litchurch, Derby, 10 a.m. ★ LONDON GRADUATES' SECTION : Visit to Hancock and Co. (Engineers), Ltd., Croydon, 10 a.m

INSTITUTION OF PLANT ENGINEERS

Mon., Feb. 22.—BIRMINGHAM BRANCH : Hotel Leofric, Coventry, "Modern Welding Methods," R. T. Andrews, 7.30 p.m.
Tues., Feb. 23.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2, "Some Problems in the Design of Large Rocket-Engine Test Beds," R. H. B. Forster and L. Breen, 7 p.m. ★ S. WALES BRANCH : S. Wales Institute of Engineers, Park Place, Cardiff, "Metal Stitching," N. Tinwell, 7.30 p.m.
Thurs., Feb. 25.—SHEFFIELD AND DISTRICT BRANCH : Grand Hotel, Sheffield, Annual General Meeting followed by papers by members, 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Feb. 22.—MANCHESTER SECTION : Engineers' Club, Albert Square, Manchester, "Towards the Quantitative Understanding of Rubbers," G. Gee, 6.45 p.m. ★ MERSEYSIDE SECTION : Exchange Hotel, Liverpool, "Problems of the Rubber Industry," W. F. Watson, R. C. Davies, J. D. Crabbe and J. H. Carrington, 7.15 p.m.

INSTITUTION OF WATER ENGINEERS

Wed., Feb. 24.—Institution of Civil Engineers, Great George Street, London, S.W.1, Films, "Work and Training of Mains and Waste Inspectors," and "Hyperion—the World's Longest Sea-Outfall," 2.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 19.—Pepys House, 14, Rochester Row, London, S.W.1, "The Design Features of Large Radio Telescopes," J. Heywood, 7 p.m.
Fri., Feb. 26.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The Manufacture and Use of Metal Sinterings," B. H. Swan, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Feb. 26.—Engineers' Club, Albert Square, Manchester, "The Development of the Piano Milling Machine," J. Atherton, 6.45 p.m.

PLASTICS INSTITUTE

To-day, Feb. 19.—MIDLANDS SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, 3, "Polyacetal Resin," 6.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Thurs., Feb. 25.—WEST OF ENGLAND BRANCH : New School of Engineering, The University, Bristol, "Soil Mechanics and Foundation Engineering," W. J. Larnach, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Feb. 23.—Library, Royal Aeronautical Society, 4, Hamilton Place, London, W.1, "Relationship Between Theory and Practice in Structural Problems," A. J. Troughton, 7 p.m.

ROYAL SOCIETY OF ARTS

Mon., Feb. 22.—CANTOR LECTURE : John Adam Street, Adelphi, London, W.C.2, "The Fuel and Power Industries and National Prosperity—Production and Treatment of Coals and Oils," A. Parker, 6 p.m.
Wed., Feb. 24.—TRUEMAN WOOD LECTURE : John Adam Street, Adelphi, London, W.C.2, "The Exploration of Outer Space," A. C. B. Lovell, 2.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Feb. 23.—CONTROL AND DATA PROCESSING SECTIONS : Manson House, 26, Portland Place, London, W.1, "Back-scatter Method of Wall Thickness Measurement," D. F. White and L. E. Taylor, "Ultrasonic Resonance Method of Wall Thickness Measurement," M. V. James, 6.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, Feb. 19.—39, Elmbank Crescent, Glasgow, "Application of Electron Microscopy in Steel Research," F. B. Pickering, 6.45 p.m.

Advanced Engineering Courses

O.E.E.C. Courses on Nuclear Energy for Engineers and Technical Industrialists. Two international courses arranged by the European Nuclear Energy Agency of the O.E.E.C. One course will be at the Centre d'Etudes Nucléaires at Saclay, France, and the other at the Atomic Energy Research Establishment, Harwell. Each course will be open to some fifty participants from O.E.E.C. countries, and will cover the technical, economic and industrial aspects of nuclear energy. The course at Saclay (French language) will take place from June 27 to July 8 ; the Harwell course, in English, from July 4 to 15. Further information can be obtained from O.E.E.C. European Nuclear Energy Agency, 38, Boulevard Suchet, Paris, 16e.

Secondary Surfaces for Heat Exchangers. NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, St. John Street, London, E.C.1. A course of six lectures for students who are graduates in science or engineering or those with equivalent qualifications. Students will be expected to have a good knowledge of heat transfer. Wednesday evenings at 7 p.m., commencing March 2. Fee £1 1s.

Refresher Courses for Older Graduates. DEPARTMENT OF METALLURGY, BATTERSEA COLLEGE OF TECHNOLOGY, London, S.W.11. Three- to four-day courses by members of the College staff and visiting lecturers. "The Structure of Metals and Alloys," Easter vacation, April ; "Developments in Foundry Practice," Summer vacation, July : "Austenite Transformation—The Present Position," Summer vacation, September.

Institution of Municipal Engineers. Connaught Rooms, Great Queen Street, London, W.C.2. Biennial spring school, March 2 to 4. March 2 : "Highways," "Motorways Construction," Col. Ffolliott. "City Traffic," R. Nicholas. "The Design of Road Improvements in an Urban Area," S. E. French. March 3 : "Housing and Town Planning," "Civic Design in Magdalen Street," Misha Black. "Current Planning Problems," J. G. Jefferson. "Town and Country Planning," S. G. Wardley. "Work Study—Housing Repairs," J. A. Kenyon. March 4 : "The Treatment and Disposal of Sewage Sludge," W. Fillingham Brown. "Refuse Collection and Disposal," P. V. Marchant. "Paints for Municipal Use," C. A. Chaplin. "Landscaping Tree Preservation," Film by Civic Trust and Talk.

Operational Research. INSTITUTE FOR ENGINEERING PRODUCTION, THE UNIVERSITY OF BIRMINGHAM, 16, Norfolk Road, Birmingham, 15. The general purpose of the course is to enable industrial managers, senior production engineers and operational research and work study specialists to meet together with leading authorities in the operational research field and to engage upon discussions and group studies on modern developments in the application of operational research to industrial productivity problems. The course runs from 9.30 a.m., Monday, April 4, until 5.30 p.m., Thursday, April 14. Inclusive charge for the two-week residential course is fifty-five guineas.

Health Physics (Radiation Protection). NUCLEAR TECHNOLOGY LABORATORIES, DEPARTMENT OF CHEMICAL ENGINEERING AND CHEMICAL TECHNOLOGY, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, South Kensington, London, S.W.7. A summer school in health physics (radiation protection) arranged by Hugh D. Evans. The course will be of two weeks' duration, starting on Monday, July 4, and should be of interest to university radiation protection officers, industrial safety officers concerned with radiation and radioactive hazards, medical officers of health, factory inspectors and others concerned with radiation protection. Fee twenty-five guineas (exclusive of residence).

Metal Fatigue. THE UNIVERSITY, BRISTOL. The course runs from March 28 to April 1 and is intended for engineers and for metallurgists and physicists interested in engineering matters. Fee five guineas, charge for accommodation at the Hawthorns Hotel, ten guineas.

The Design of Industrial Experiments. INSTITUTE FOR ENGINEERING PRODUCTION, THE UNIVERSITY OF BIRMINGHAM, 16, Norfolk Road, Birmingham, 15. The course, which will be held from 9.30 a.m., Monday, March 21, until 3.30 p.m., Friday, April 1, covers the theory of experimental design from the basic principles to the analysis and interpretation of the results. Inclusive charge for the two-week residential course is fifty-five guineas.

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INSTITUTION OF ELECTRICAL ENGINEERS

Sat., Feb. 20.—LONDON GRADUATE AND STUDENT SECTION: Visit to Houses of Parliament (Plant Room and Technical Services), 10.30 a.m.
Mon., Feb. 22.—INFORMAL MEETING: Savoy Place, London, W.C.2, Discussion on "Are We Making the Best Use of Research Resources?" opened by L. Rotherham, 5.30 p.m. ★ EAST ANGLIAN SUB-CENTRE: Technical College, Cambridge, Discussion on "The Provision of Adequate Electrical Installations in Buildings," 6.30 p.m. ★ MERSEY AND NORTH WALES CENTRE: Town Hall, Chester, Joint meeting with the North-Western Centre; "A Frequency-Response Method for the Predetermination of Synchronous-Machine Stability," A. S. Aldred and G. Shackshaft, 6.30 p.m. ★ NORTH-EASTERN CENTRE: Neville Hall, Westgate Road, Newcastle upon Tyne, "The Characteristics and Protection of Semiconductor Rectifiers," D. B. Corbyn and N. L. Potter, 6.15 p.m. ★ SOUTH MIDLAND ELECTRONICS AND MEASUREMENT GROUP: James Watt Memorial Institute, Birmingham, "Silicone Transistors—Their Manufacture and Fields of Application," J. T. Kendall, 6 p.m. ★ WESTERN UTILIZATION GROUP: South Wales Institute of Engineers, Cardiff, "The Spark Machining of Hard Metals," G. H. Townend, 6 p.m.
Tues., Feb. 23.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "Courses for Electrical Technicians," opened by M. W. Humphrey Davies, 6 p.m. ★ NORTH-WESTERN SUPPLY GROUP: Engineers' Club, Albert Square, Manchester, "The Application of Low-Pressure Resins to Some High-Voltage Switchgear Designs," T. R. Manley, K. Rothwell, and W. Gray, 6.15 p.m. ★ NORTHERN IRELAND CENTRE: David Keir Building, Queen's University, Stranmillis Road, Belfast, "The Linear Induction Motor," E. R. Laithwaite, 6.30 p.m. ★ SOUTH-WEST SCOTLAND SUB-CENTRE: Royal College of Science and Technology, Glasgow, "Ultra-Sound Image Camera," C. N. Smyth and J. Sayers, 6 p.m.
Wed., Feb. 24.—ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, "Applications of Microwaves," A. L. Cullen, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION: Visit to Post Office, Research Station, Dollis Hill, London, N.W.2, 2.15 p.m. ★ SOUTH-EAST SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "Ultra-Sound Image Camera," C. M. Smith, and J. Sayers, 7 p.m. ★ SOUTHERN CENTRE: Central Telephone Exchange, Park Road, Portsmouth, "Development of the Formulae of Electro-Magnetism in the M.K.S. System," P. Vigoureux, 6.30 p.m.
Thurs., Feb. 25.—NORTH MIDLAND CENTRE: Y.E.B. Offices, Ferensway, Hull, "Subscriber Trunk Dialling," D. A. Barron, 6.30 p.m. ★ WESTERN UTILIZATION GROUP: Demonstration Theatre, S.W.E.B., Kingsway, Swansea, "The Organisation of Industrial Electrical Maintenance," S. R. Phelps, 6 p.m.
Mon., Feb. 29.—NORTH-EASTERN MEASUREMENT AND ELECTRONICS GROUP: Rutherford College of Technology, Newcastle upon Tyne, "Radio Aspects of the International Geophysical Year," R. L. Smith-Rose, 6.15 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Fri., Feb. 26.—Robert Gordon's Technical College, Aberdeen, "Vibration Problems in Marine Machinery and their Solution," W. McLaughlin, 7.45 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

To-day, Feb. 19.—NORTH-EAST BRANCH: Municipal Buildings, Middlesbrough, "The Design and Installation of Corrugated Metal Structures," P. R. S. Holmstrom, 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 19.—YORKSHIRE GRADUATES' SECTION: Royal Station Hotel, Hull, "What Do You Know About Patents?" T. A. Hulse, 7 p.m.
Mon., Feb. 22.—EDUCATION GROUP DISCUSSION: 1, Birdcage Walk, Westminster, London, S.W.1, "The Place of Management Studies in the Training of an Engineer," 6 p.m.
Tues., Feb. 23.—LUBRICATION GROUP DISCUSSION: 1, Birdcage Walk, Westminster, London, S.W.1, "Water Lubrication," 6 p.m. ★ WESTERN BRANCH: Engineering Laboratories, The University, Bristol, "The Gas Turbine Engine in Civil Aviation," S. G. Hooker, 6.30 p.m. ★ BIRMINGHAM AUTOMOBILE DIVISION: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Mechanical Design and Performance of the Petrol Engine," W. V. Appleby, 6.30 p.m. SCOTTISH GRADUATES' SECTION: Visit to Hoover (Electric Motors), Ltd., Cambuslang, Lanarkshire, 7 p.m.
Wed., Feb. 24.—ORDINARY MEETING IN CONJUNCTION WITH THE STEAM GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Wetness in Steam Cycles," B. Wood, 6 p.m. ★ YORKSHIRE BRANCH: Royal Station Hotel, Hull, "Marine Refrigeration," H. R. Howells, 7.30 p.m. ★ EASTERN GRADUATES' SECTION: Visit to W. H. A. Robertson, Bedford, 7.30 p.m. ★ SOUTHERN GRADUATES' SECTION: Recreational Society Pavilion, Aldermaston, "Comparative Properties of Rubber," E. Gunn, 3 p.m.
Thurs., Feb. 25.—N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "A Review of Nuclear Reactor Developments," R. V. Moore, 6.45 p.m. ★ WESTERN AUTOMOBILE DIVISION: Royal Hotel, Bristol, "Automobile Steering Suspension and Tyres," D. Bastow, 6.45 p.m. ★ E. MIDLANDS GRADUATES' SECTION: College of Further Education, Loughborough, "Electronics for the Mechanical Engineer," M. J. Hamblin, 7.15 p.m. ★ LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, "Some Aspects of Aircraft Flight and Crash Protection with Emphasis on the Power Plant," F. A. A. Palmer, 6.30 p.m.
Sat., Feb. 27.—E. MIDLANDS GRADUATES' SECTION: Visit to British Transport Commission Carriage and Wagon Works, Litchurch, Derby, 10 a.m. ★ LONDON GRADUATES' SECTION: Visit to Hancock and Co. (Engineers), Ltd., Croydon, 10 a.m

INSTITUTION OF PLANT ENGINEERS

Mon., Feb. 22.—BIRMINGHAM BRANCH: Hotel Leofric, Coventry, "Modern Welding Methods," R. T. Andrews, 7.30 p.m.
Tues., Feb. 23.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2, "Some Problems in the Design of Large Rocket-Engine Test Beds," R. H. B. Forster and L. Breen, 7 p.m. ★ S. WALES BRANCH: S. Wales Institute of Engineers, Park Place, Cardiff, "Metal Stitching," N. Tinwell, 7.30 p.m.
Thurs., Feb. 25.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, Annual General Meeting followed by papers by members, 7.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Feb. 22.—MANCHESTER SECTION: Engineers' Club, Albert Square, Manchester, "Towards the Quantitative Understanding of Rubbers," G. Gee, 6.45 p.m. ★ MERSEYSIDE SECTION: Exchange Hotel, Liverpool, "Problems of the Rubber Industry," W. F. Watson, R. C. Davies, J. D. Crabbe and J. H. Carrington, 7.15 p.m.

INSTITUTION OF WATER ENGINEERS

Wed., Feb. 24.—Institution of Civil Engineers, Great George Street, London, S.W.1, Films, "Work and Training of Mains and Waste Inspectors," and "Hyperion—the World's Longest Sea-Outfall," 2.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 19.—Pepys House, 14, Rochester Row, London, S.W.1, "The Design Features of Large Radio Telescopes," J. Heywood, 7 p.m.
Fri., Feb. 26.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The Manufacture and Use of Metal Sinterings," B. H. Swan, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Feb. 26.—Engineers' Club, Albert Square, Manchester, "The Development of the Plano Milling Machine," J. Atherton, 6.45 p.m.

PLASTICS INSTITUTE

To-day, Feb. 19.—MIDLANDS SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, 3, "Polyacetal Resin," 6.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Thurs., Feb. 25.—WEST OF ENGLAND BRANCH: New School of Engineering, The University, Bristol, "Soil Mechanics and Foundation Engineering," W. J. Larnach, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Feb. 23.—Library, Royal Aeronautical Society, 4, Hamilton Place, London, W.1, "Relationship Between Theory and Practice in Structural Problems," A. J. Troughton, 7 p.m.

ROYAL SOCIETY OF ARTS

Mon., Feb. 22.—CANTOR LECTURE: John Adam Street, Adelphi, London, W.C.2, "The Fuel and Power Industries and National Prosperity—Production and Treatment of Coals and Oils," A. Parker, 6 p.m.
Wed., Feb. 24.—TRUEMAN WOOD LECTURE: John Adam Street, Adelphi, London, W.C.2, "The Exploration of Outer Space," A. C. B. Lovell, 2.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Tues., Feb. 23.—CONTROL AND DATA PROCESSING SECTIONS: Manson House, 26, Portland Place, London, W.1, "Back-scatter Method of Wall Thickness Measurement," D. F. White and L. E. Taylor, "Ultrasonic Resonance Method of Wall Thickness Measurement," M. V. James, 6.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, Feb. 19.—39, Elmbank Crescent, Glasgow, "Application of Electron Microscopy in Steel Research," F. B. Pickering, 6.45 p.m.

Advanced Engineering Courses

O.E.E.C. Courses on Nuclear Energy for Engineers and Technical Industrialists. Two international courses arranged by the European Nuclear Energy Agency of the O.E.E.C. One course will be at the Centre d'Etudes Nucléaires at Saclay, France, and the other at the Atomic Energy Research Establishment, Harwell. Each course will be open to some fifty participants from O.E.E.C. countries, and will cover the technical, economic and industrial aspects of nuclear energy. The course at Saclay (French language) will take place from June 27 to July 8; the Harwell course, in English, from July 4 to 15. Further information can be obtained from O.E.E.C. European Nuclear Energy Agency, 38, Boulevard Suchet, Paris, 16e.

Secondary Surfaces for Heat Exchangers. NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY, St. John Street, London, E.C.1. A course of six lectures for students who are graduates in science or engineering or those with equivalent qualifications. Students will be expected to have a good knowledge of heat transfer. Wednesday evenings at 7 p.m., commencing March 2. Fee £1 1s.

Refresher Courses for Older Graduates. DEPARTMENT OF METALLURGY, BATTERSEA COLLEGE OF TECHNOLOGY, London, S.W.11. Three- to four-day courses by members of the College staff and visiting lecturers. "The Structure of Metals and Alloys," Easter vacation, April: "Developments in Foundry Practice," Summer vacation, July: "Austenite Transformation—The Present Position," Summer vacation, September.

Institution of Municipal Engineers. Connaught Rooms, Great Queen Street, London, W.C.2. Biennial spring school, March 2 to 4. March 2: "Highways," "Motorways Construction," Col. Ffolliott. "City Traffic," R. Nicholas. "The Design of Road Improvements in an Urban Area," S. E. French. March 3: "Housing and Town Planning." "Civic Design in Magdalen Street," Misha Black. "Current Planning Problems," J. G. Jefferson. "Town and Country Planning," S. G. Wardley. "Work Study—Housing Repairs," J. A. Kenyon. March 4: "The Treatment and Disposal of Sewage Sludge," W. Fillingham Brown. "Refuse Collection and Disposal," P. V. Marchant. "Paints for Municipal Use," C. A. Chaplin. "Landscaping Tree Preservation," Film by Civic Trust and Talk.

Operational Research. INSTITUTE FOR ENGINEERING PRODUCTION, THE UNIVERSITY OF BIRMINGHAM, 16, Norfolk Road, Birmingham, 15. The general purpose of the course is to enable industrial managers, senior production engineers and operational research and work study specialists to meet together with leading authorities in the operational research field and to engage upon discussions and group studies on modern developments in the application of operational research to industrial productivity problems. The course runs from 9.30 a.m., Monday, April 4, until 5.30 p.m., Thursday, April 14. Inclusive charge for the two-week residential course is fifty-five guineas.

Health Physics (Radiation Protection). NUCLEAR TECHNOLOGY LABORATORIES, DEPARTMENT OF CHEMICAL ENGINEERING AND CHEMICAL TECHNOLOGY, IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY, South Kensington, London, S.W.7. A summer school in health physics (radiation protection) arranged by Hugh D. Evans. The course will be of two weeks' duration, starting on Monday, July 4, and should be of interest to university radiation protection officers, industrial safety officers concerned with radiation and radioactive hazards, medical officers of health, factory inspectors and others concerned with radiation protection. Fee twenty-five guineas (exclusive of residence).

Metal Fatigue. THE UNIVERSITY, BRISTOL. The course runs from March 28 to April 1 and is intended for engineers and for metallurgists and physicists interested in engineering matters. Fee five guineas, charge for accommodation at the Hawthorns Hotel, ten guineas.

The Design of Industrial Experiments. INSTITUTE FOR ENGINEERING PRODUCTION, THE UNIVERSITY OF BIRMINGHAM, 16, Norfolk Road, Birmingham, 15. The course, which will be held from 9.30 a.m., Monday, March 21, until 3.30 p.m., Friday, April 1, covers the theory of experimental design from the basic principles to the analysis and interpretation of the results. Inclusive charge for the two-week residential course is fifty-five guineas.

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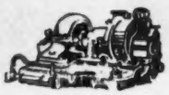

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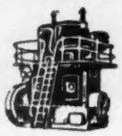

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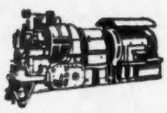

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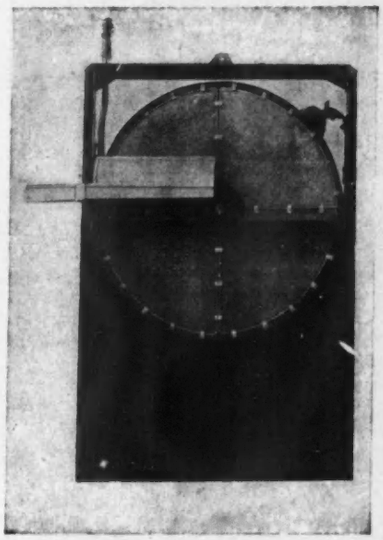

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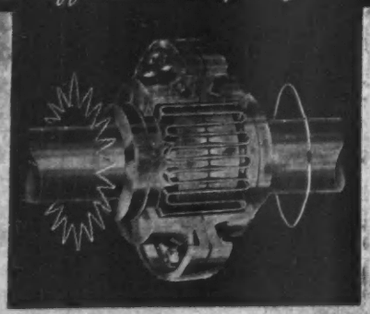

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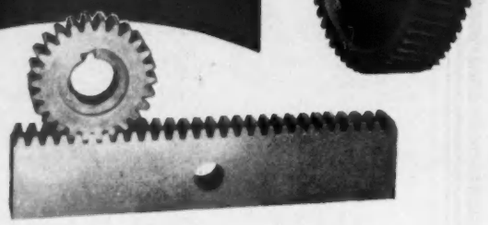

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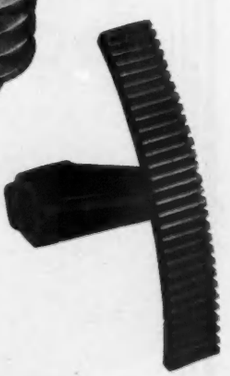

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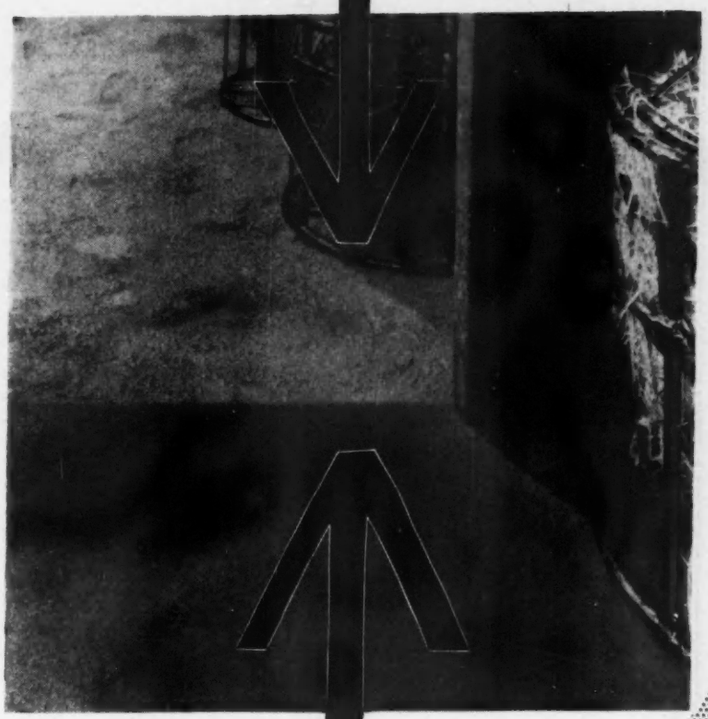

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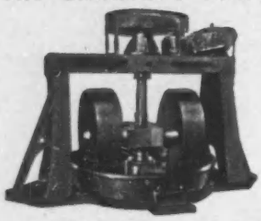

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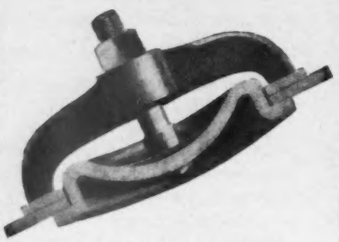

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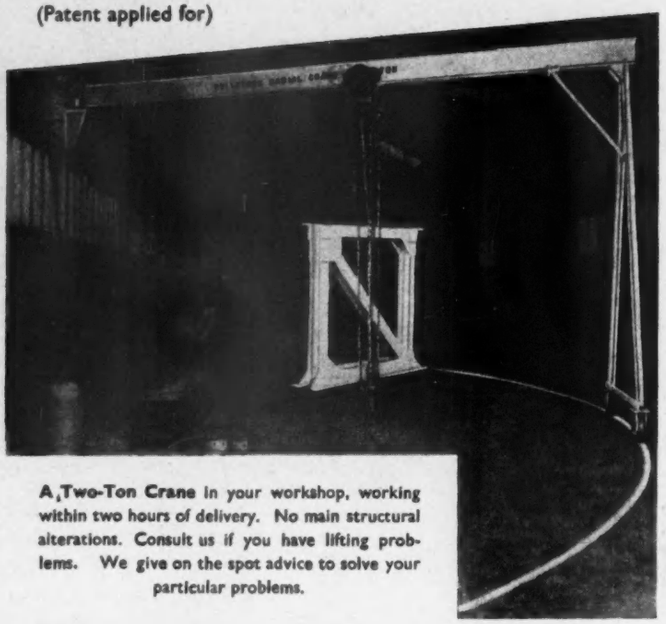

A Two-Ton Crane in your workshop, working within two hours of delivery. No main structural alterations. Consult us if you have lifting problems. We give on the spot advice to solve your particular problems.

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- This Strateline unit has an output capacity of 7,000 lbs. ins. required by maximum out of balance conditions whilst working on the Engine.
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- Self-sustaining Strateline mechanism which operates when movement of handle ceases—the engine can be rotated, and sustained at any position, through 360°

The photograph above shows the type CW1 Strateline unit fitted to a Rolls Royce Dart Aero Engine Overhaul Stand designed and manufactured by Messrs. Morfax Limited of Mitcham, Surrey. The high efficiency and compact assembly of the Strateline makes it particularly suitable for manual operation and many variations have been supplied for high pressure valve operation, hand winch units, furnace tilting, etc. Where reasonable quantities are involved we are prepared to design special units against particular applications.

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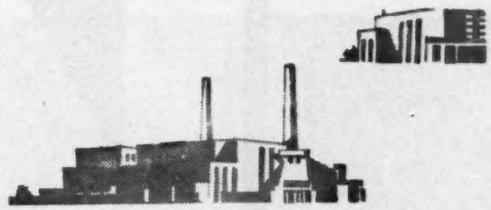
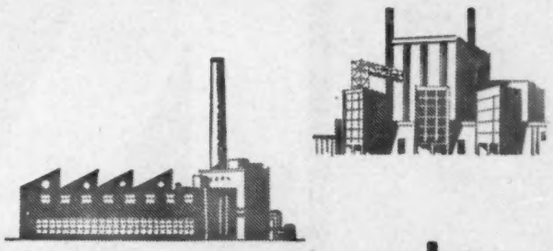
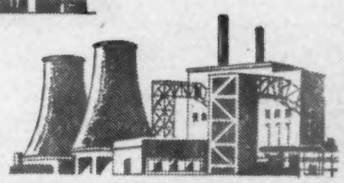


Designed for modern industry, Mercedes-Benz Diesel Power Units bring you power on the spot—where you want it, when you want it—reliable, economic power that can be used in all branches of industry for countless applications.

The engines range from 17 to 71 h.p. and provide a source of power for pumps, lifts, drills, excavators, conveyor belts—in sugar refineries, saw mills, brick works, on building sites—anywhere!





Completely self-contained, Mercedes-Benz Diesel Power Units are built for reliability, easy-handling, simple maintenance, and can be run at the lowest possible operating costs. They have full instrumentation, weather-proof cowlings, a cooling system sufficient for 50°C ambient temperature and the output couplings can be supplied to suit users' requirements.

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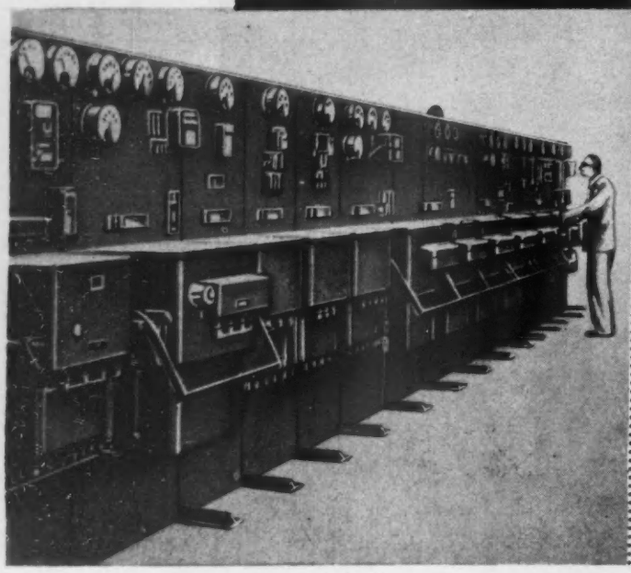
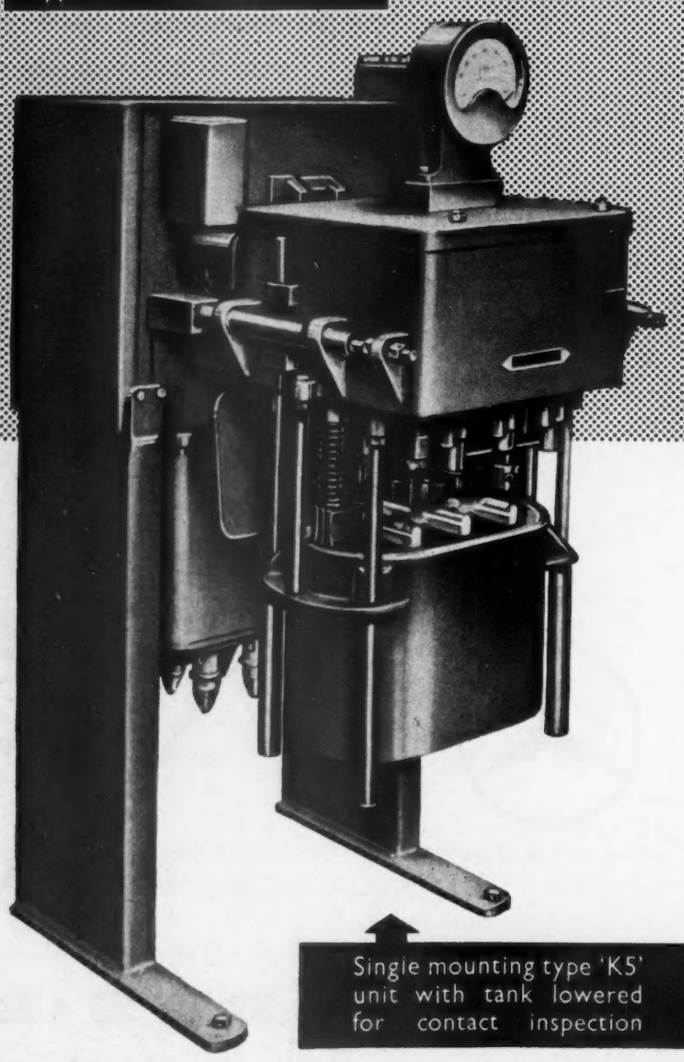
TYPES K & KC

Industrial Switchgear

Rating—up to 660v./2000a.



Switchboard consisting of types 'KC6' and 'KC4' units



Single mounting type 'K5' unit with tank lowered for contact inspection

Types K & KC Switchgear have been specially designed to provide a reliable power supply for industrial and commercial needs where the rating required is not in excess of 660V-2000A.

The Switchgear is available for pedestal or cubicle mounting and incorporates horizontal drawout circuit-breakers suitable for the control of all main and auxiliary power supplies.

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For further particulars write to AEI Switchgear Division, Higher Openshaw, Manchester, or to your local AEI office.

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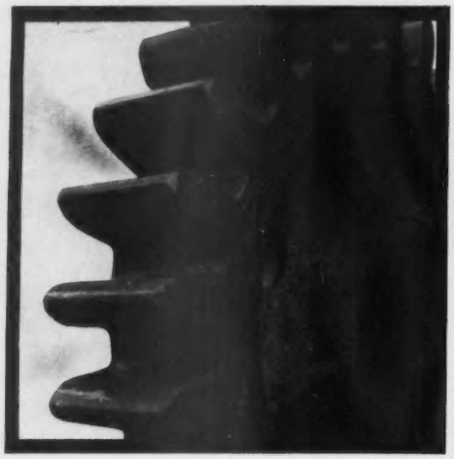

A 25T (5½" deep) Spur Wheel to work at varying centres, reconditioned by the Dilloway method. All teeth built up and machined to correct contours.

A Helical Pinion with Wobbler ends. Teeth built up and machined to correct contours; wobbler ends built up and ground to standard.

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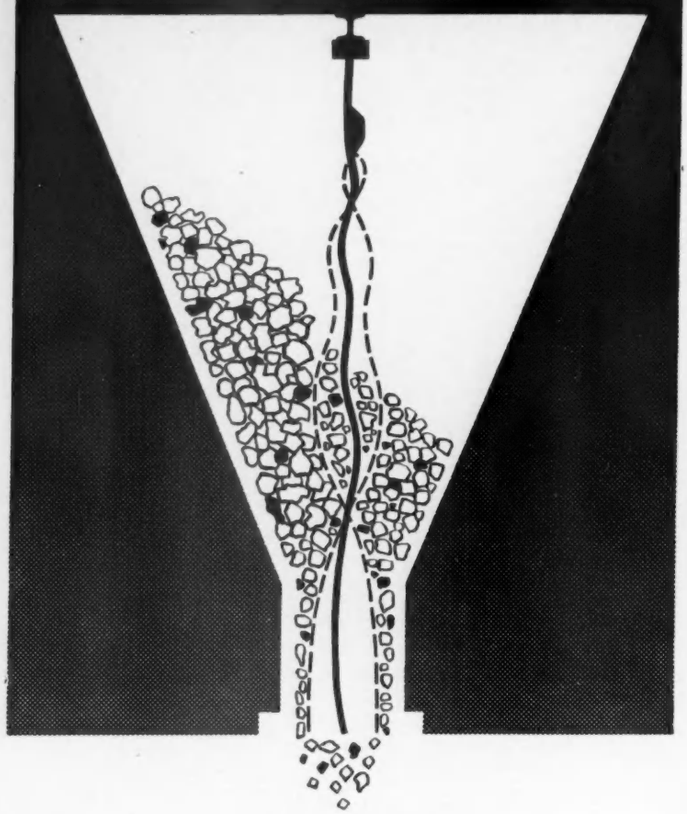
Efficient Bunker Discharge



The problems of efficient discharge of material from large storage bunkers where external vibration is impractical is simply overcome by the installation of the new Sinex Internal Bunker Vibrator. The device comprises a Sinex rotary electric vibrator attached to a steel reed which hangs down into the bunker. The unit is suspended from a rolled steel joist and anti-vibration mountings protect the hopper structure itself. Maximum amplitude occurs at the tip of the reed or at the point where stoppage has built up, releases the material and ensures a smooth, free flow. Sinex Internal Bunker Vibrators are completely reliable, the power unit being readily accessible and causing no obstruction to the material inside the hopper.

Sinex

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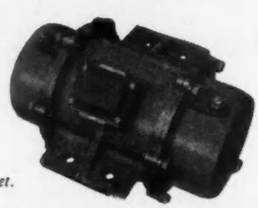

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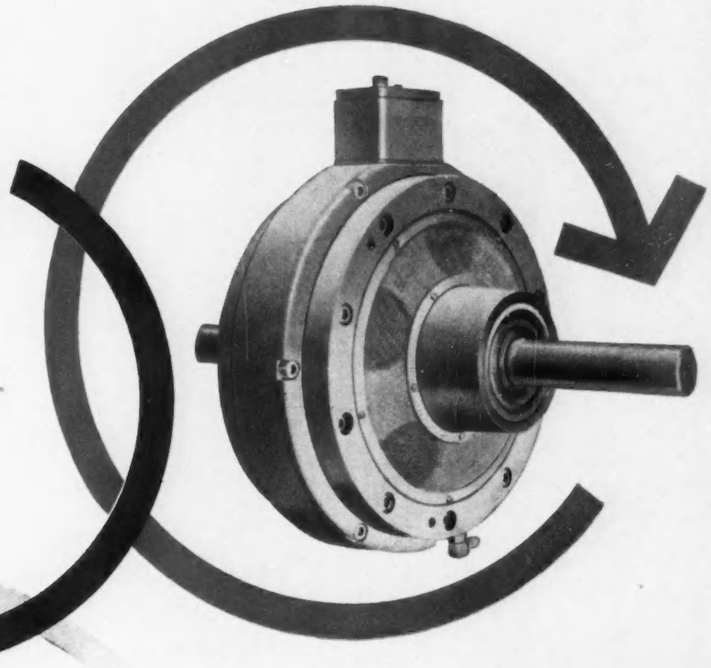
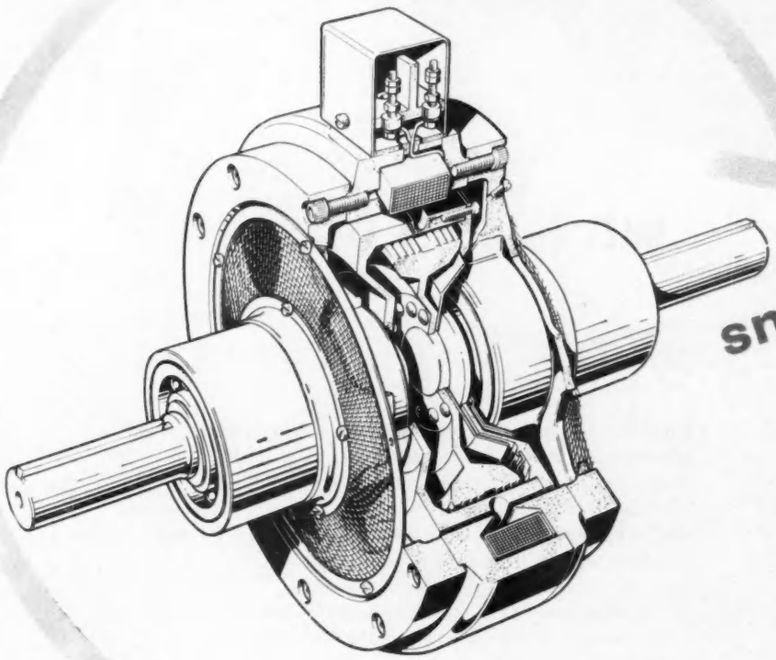
SMITHS

Magnetic Particle COUPLING





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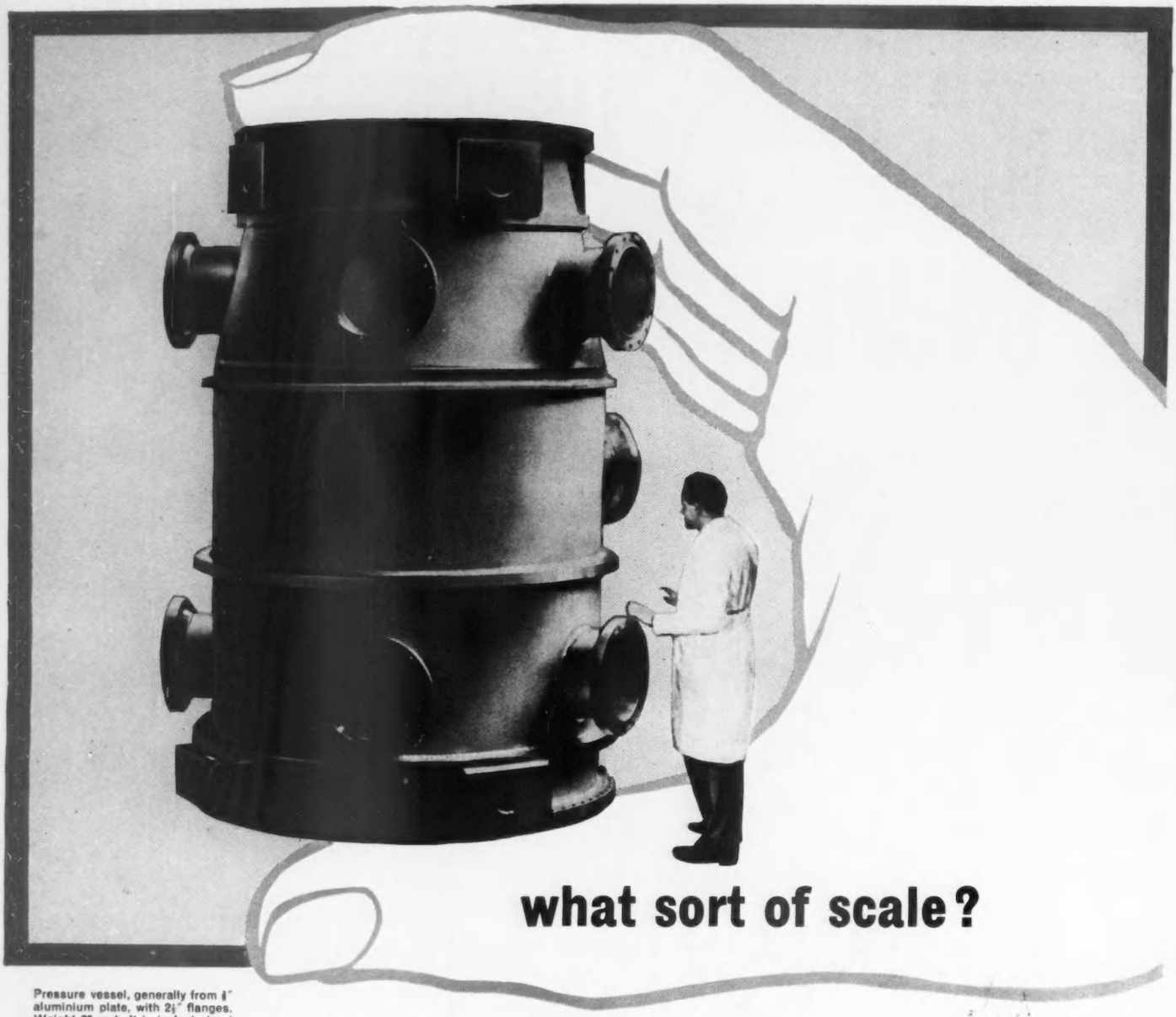

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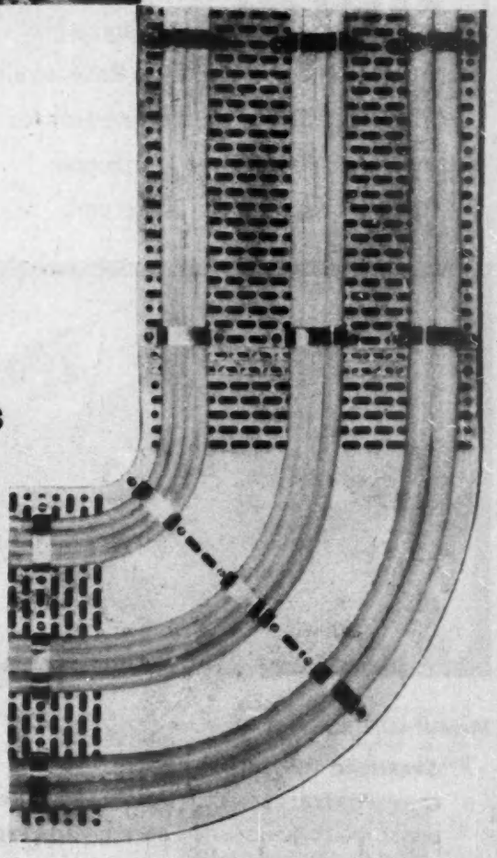

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L

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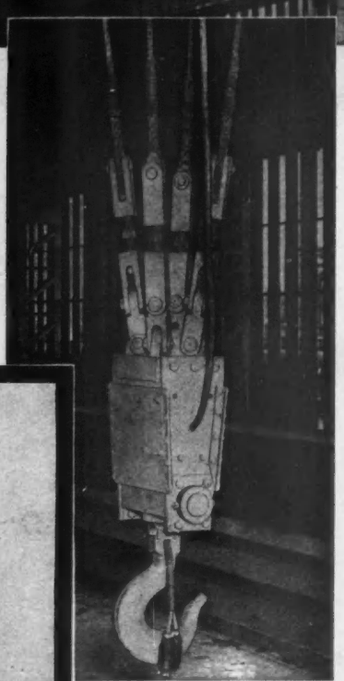
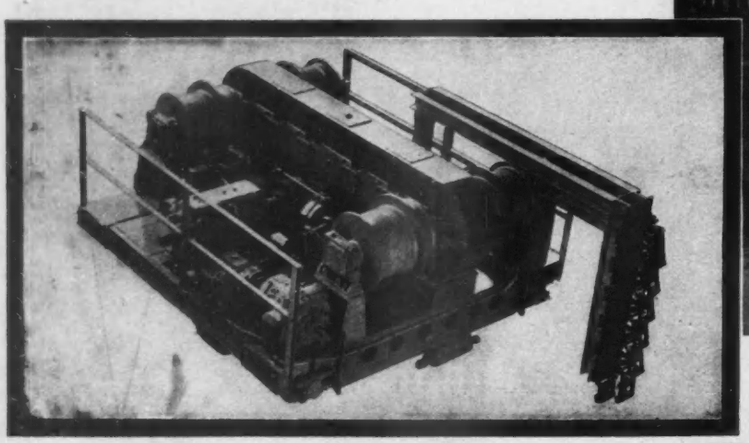
(ABOVE) Clyde-Booth four point suspension electric overhead travelling magnet crane at Messrs. Colvilles Ltd., Ravenscraig Works.
(RIGHT) The hook with slip-ring gear for the magnet, showing attachment of the four ropes.
(BELOW) The special four barrel crab.





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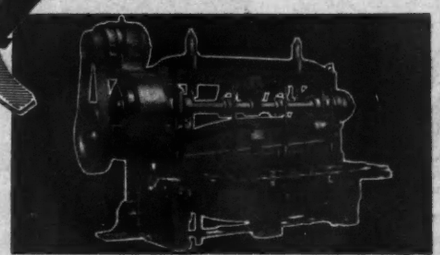

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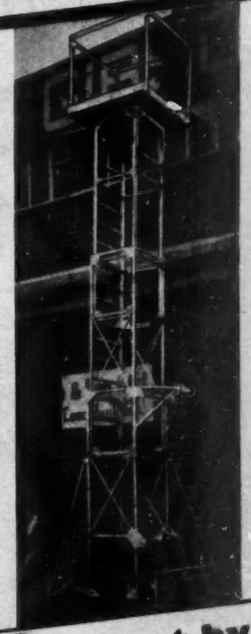

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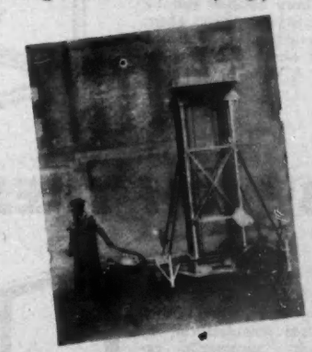

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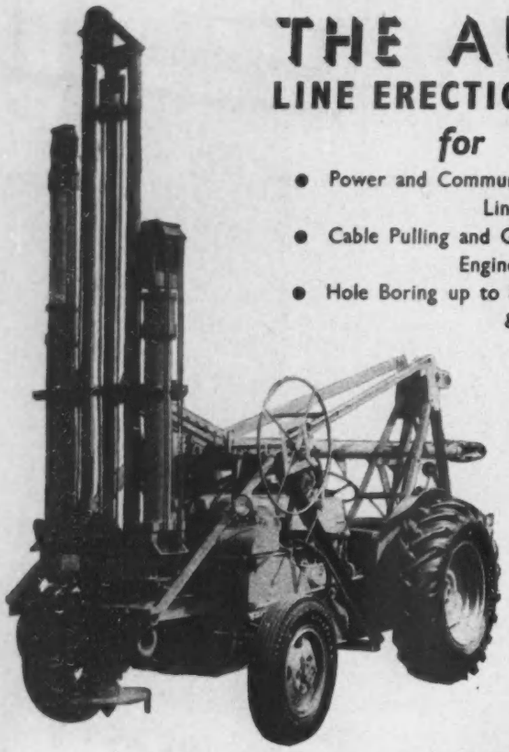

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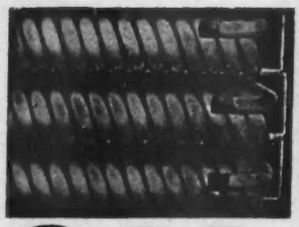

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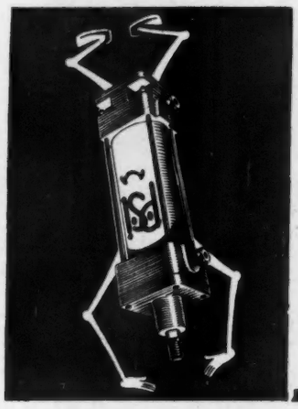

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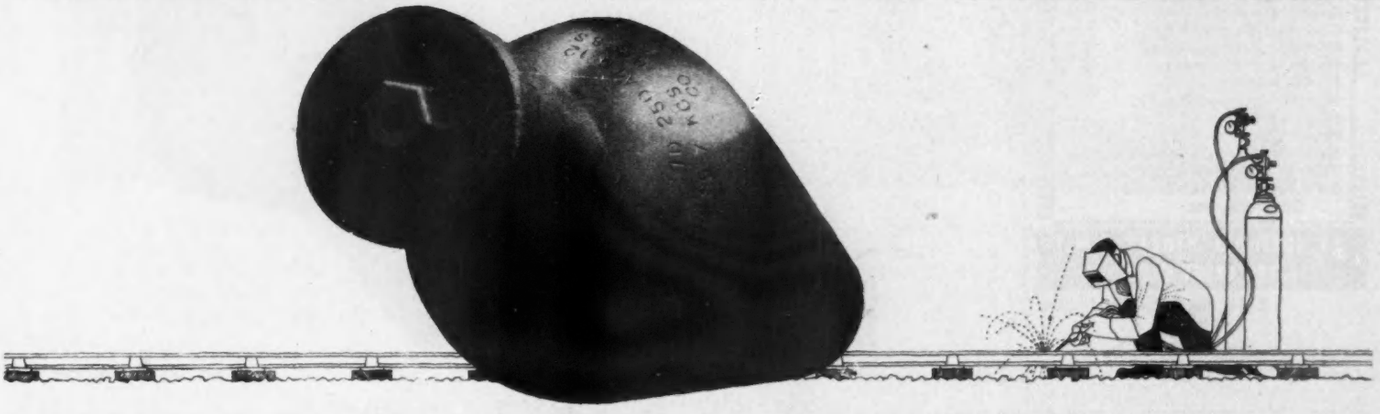

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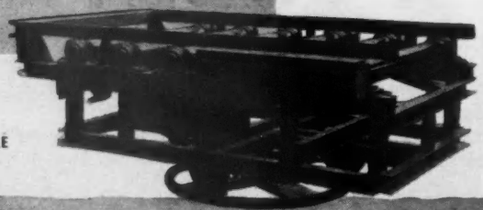
ROBSON CONVEYORS
ESTABLISHED 1906



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CONTROLLED ATMOSPHERE GENERATORS

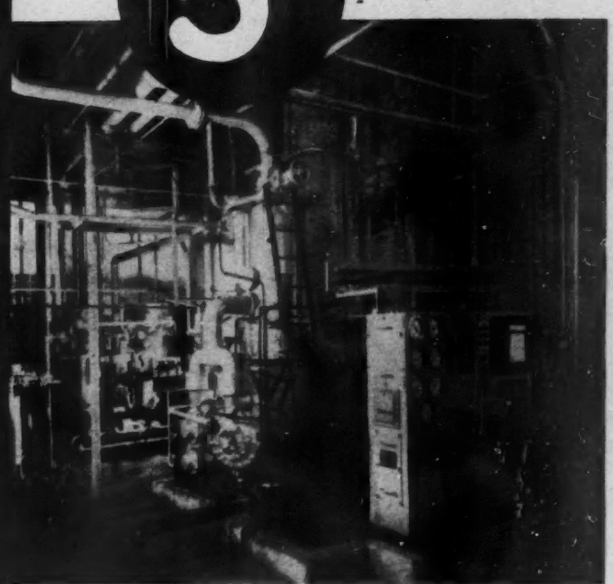
INERT GAS

at 3/- per 1,000 cubic feet.

Two Holmes-Kemp Inert Gas Generators installed at the Speke Works, Liverpool, of Messrs. Beck Koller & Co. (England) Ltd. Each of these machines is capable of producing 3,000 cubic feet of gas per hour.

NITROGEN

at 5/- per 1,000 cubic feet.



A Holmes-Kemp Nitrogen Generator installed at the Hythe Works of The International Synthetic Rubber Co. Ltd. This machine is capable of producing 3,000 cubic feet of dry nitrogen gas per hour at a pressure of 150 p.s.i.g.

By the use of Holmes Controlled Atmosphere Generators, a high quality inert gas or nitrogen can be produced on site at a fraction of the cost of bottled gases.

The advantages of generating gases in this way are obvious; they can be piped to any point on site where they will be instantly available; they can be compressed and stored; supplies are virtually unlimited and the generator being fully automatic requires a minimum of maintenance.

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Gas Handling Division, Turnbridge, Huddersfield

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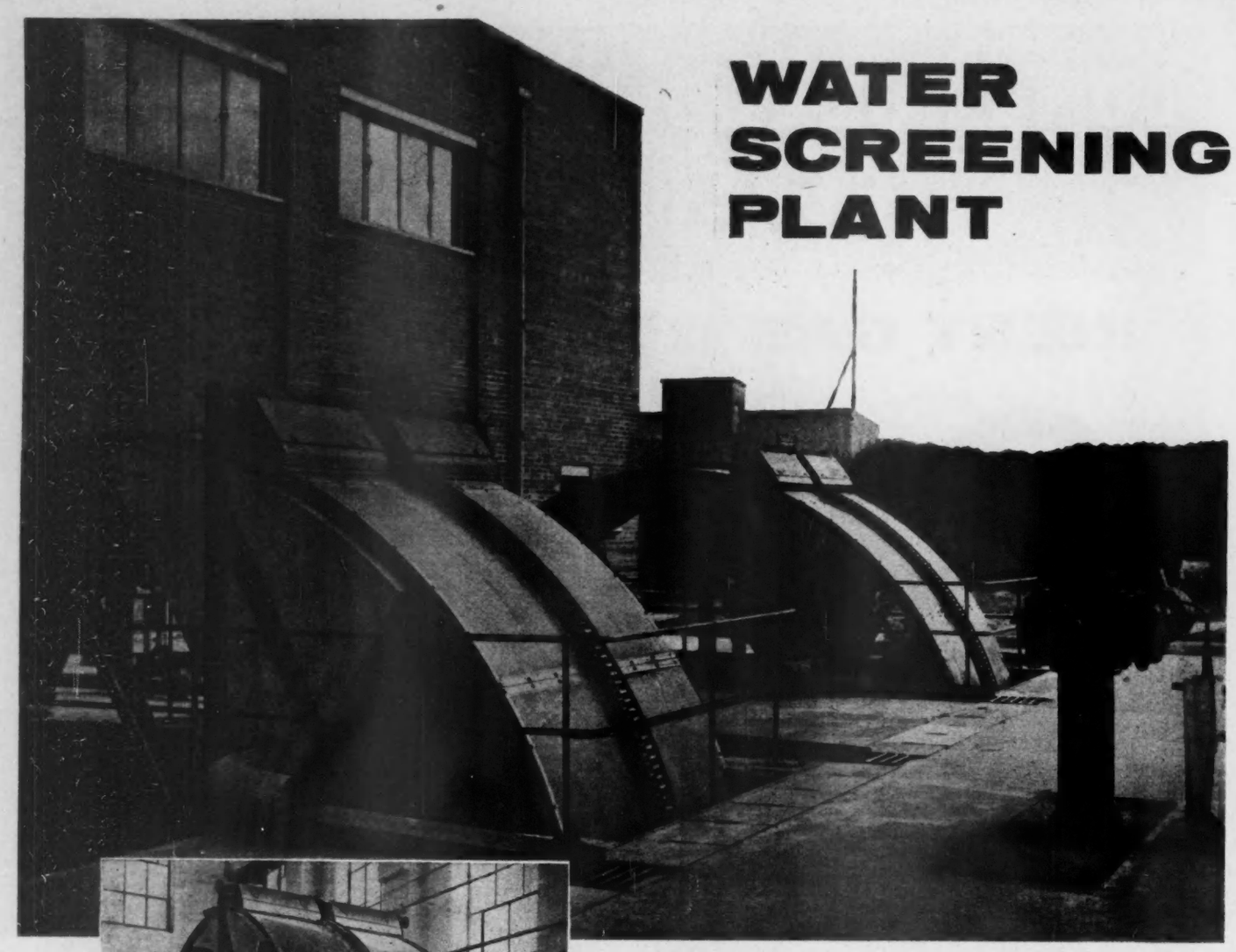
WATER SCREENING PLANT



Built to the most advanced specifications for efficient service, with low operating costs, high resistance to wear and corrosion, and ability to withstand full overload in emergency, Blakeborough self-cleaning screens have proved their value many times over on power station circulating water and other applications.

The examples illustrated are of Revolving Drum pattern. Amongst recent orders for this type are the four 38ft. diameter units supplied for Kincardine Power Station of the South of Scotland Electricity Board ; and the six 30ft. diameter units at present in hand for Uskmouth Power Station, of the Central Electricity Generating Board.

The headstock visible on the right of the installation view belongs to the motor-operated screen chamber penstock—another notable Blakeborough speciality.

BLAKEBOROUGH

J. BLAKEBOROUGH & SONS LTD · BRIGHOUSE · ENGLAND.

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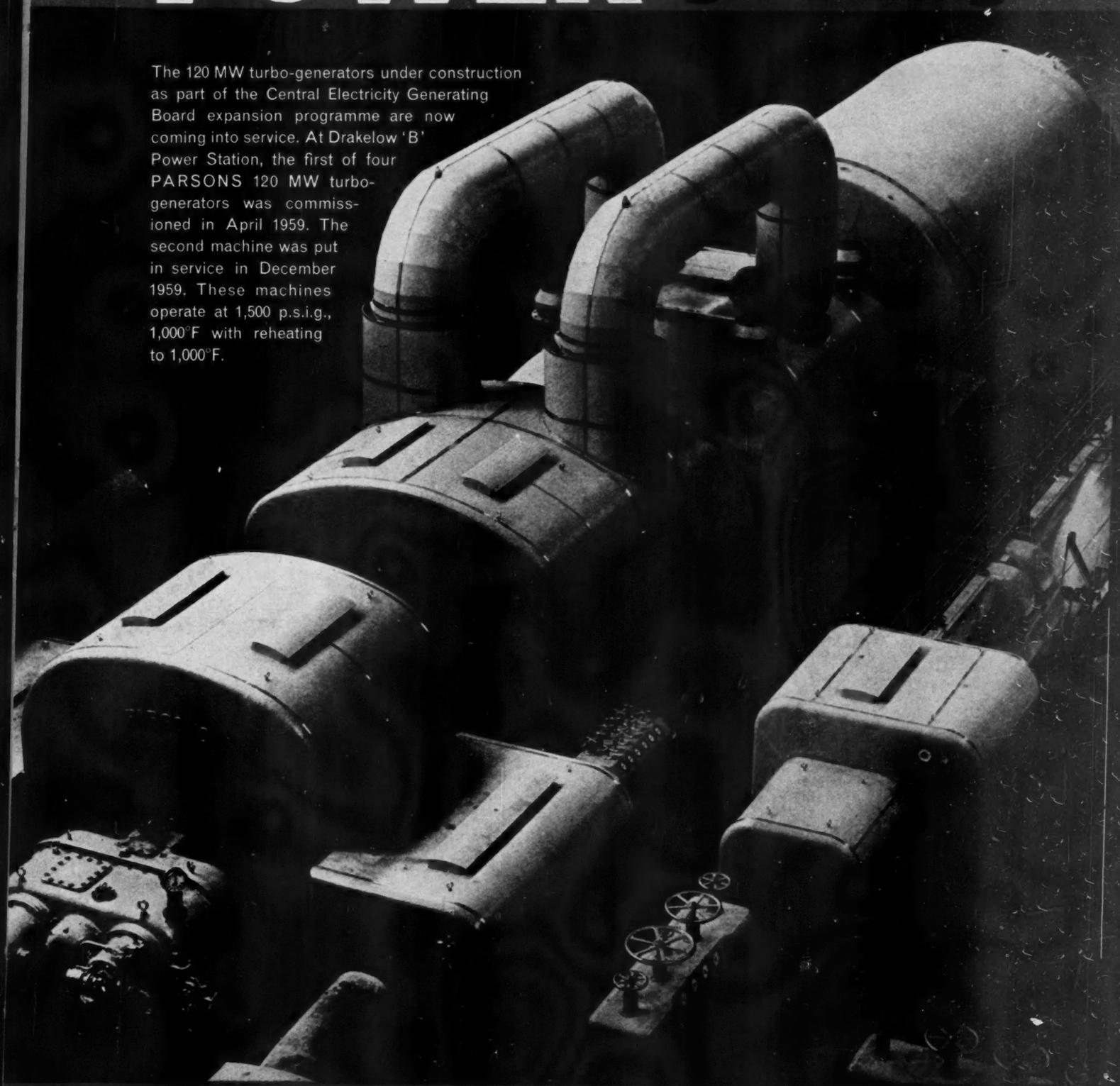
POWER

. . . another "120 MW" now generating



The 120 MW turbo-generators under construction as part of the Central Electricity Generating Board expansion programme are now coming into service. At Drakelow 'B' Power Station, the first of four PARSONS 120 MW turbo-generators was commissioned in April 1959. The second machine was put in service in December 1959. These machines operate at 1,500 p.s.i.g., 1,000°F with reheating to 1,000°F.

PARSONS

C. A. PARSONS & CO. LTD. · HEATON WORKS · NEWCASTLE UPON TYNE

COLES DIESEL-ELECTRIC

COLES CRANES

THE NAME THAT CARRIES WEIGHT IN YOUR INDUSTRY

The user value design features of COLES SELF-PROPELLED, TRUCK-MOUNTED and SHUNTING LOCO CRANES are appreciated by most of the biggest names and projects in the world. Here are some of them:

Snowy River Hydro-Electric Scheme; U.S.A. International Missile programme; every U.K. atomic project; Woomera Rocket Range; Boeing, Bristol Aircraft, De Havilland, Douglas Aircraft, Fairey Aviation, Handley Page, Hawker Siddeley, Saunders-Roe and Vickers-Armstrongs. Coles are in service with I.C.I.; Ports from London to Freemantle; Steelworks from Ravenscraig to Durgapur; B.P., Esso, Shell, Mobil; U.K., U.S.A. armed forces and most other forces throughout the world.

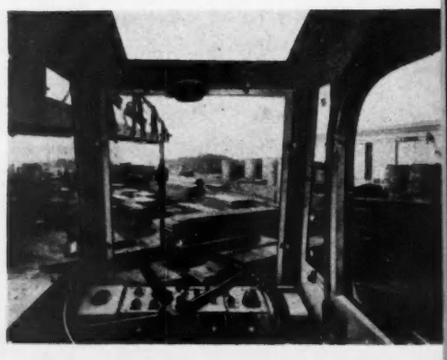
Coles handled Admiral Byrd's giant Sleighs, constructed for the Geophysical Year exploration; they unloaded Sir Vivian Fuchs' Sno-Cats, after the successful Trans-Antarctic exploration; a Coles Crane helped build 'Atomville' —the atomic village that serves the Monte Bellos Rocket Range in Australia.

For their outstanding combination of strength, mobility and accuracy with exceptional power flexibility, Coles have been chosen to carry out many important and precise operations, such as handling safely the largest piece of glass in the world and the costliest Rubens painting, 'Adoration of the Magi'. Coles Cranes were used in the loading and unloading of the statue of Christopher Columbus, shipped from Genoa to Columbus, Ohio.

* REGISTERED TRADE MARK

WIDE VISION CAB

Designed for maximum comfort plus efficiency, the operator is situated in a forward position on the full-circle-slewing superstructure—his eye is always on the hook, with large wide vision windows giving an unrestricted view of your working area.



ELECTRIC TRANSMISSION

Efficient and robust Electric Transmission provides a fully controlled smooth flow of power at the touch of a switch, with easy operation and simple maintenance without specialised knowledge. Hoist, slew, derrick and travel motions are independently powered and operated individually or in combination as required, with an infinite range of speeds from zero to maximum.

CRANES *are an investment in design*

ONLY COLES CAN CLAIM :—

(1) THE GREATEST ANNUAL PRODUCTION OF MOBILE CRANES.

(2) THE WIDEST RANGE OF LIFTING CAPACITIES.

(3) THE LARGEST MOBILE CRANE MANUFACTURING PLANT IN EUROPE.

(4) CRANE FACTORIES IN FULL PRODUCTION IN GREAT BRITAIN, U.S.A., AUSTRALIA AND WESTERN GERMANY.

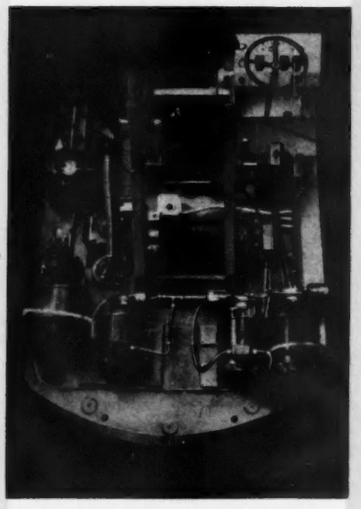
(5) MORE CRANES IN SERVICE THAN ANY OTHER MAKE OF MOBILE CRANES.

. . . and over 80 years' experience of the biggest, toughest and most complicated handling jobs is behind the design of Coles new range of Diesel-Electric Cranes ; from Concrete to Air Engines, Coles flexibility counts.

When you use Coles you achieve speed and precision with safety.

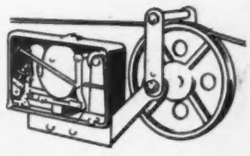
UNIT CONSTRUCTION

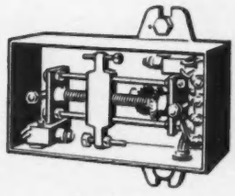
Coles Cranes are designed for maximum work with minimum maintenance ; this clean, simple layout ensures easy maintenance with quickly removable, self-contained, totally-enclosed units. The superstructure base is accurately machined to receive the self-contained units of hoist, derrick and slew motions, power unit and generator. Easily removed panelling gives maximum weather protection and quick accessibility for ease of servicing.

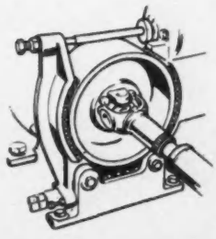


FINGER-TIP CONTROL

After only a few minutes instruction anyone can operate a Coles Crane. Pilot switches and accelerator are grouped together for easy, fatigue-free operation ; every control movement is instinctive, leaving the operator free to concentrate upon signals and his load. Coles finger-tip electric control ensures a fresh, alert operator efficient to the end of the day—a vital safety factor.







SAFETY

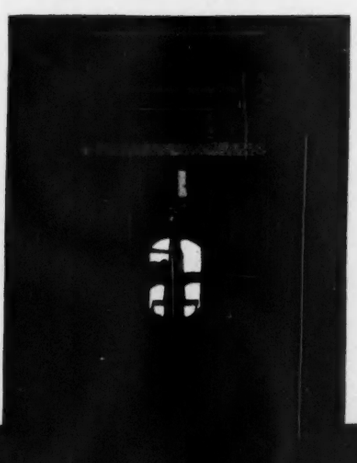
Coles many safety devices remove the human element risk and give the operator the security and confidence which enable him to work efficiently under all circumstances. In addition to the visual radius indicator which shows the safe working load, an automatic safe load indicator is fitted to weigh the load at a given radius, also giving the operator visual and audible warning of any tendency to overload—while preventing automatically the lifting of an unsafe load, irrespective of jib positions.

PRECISION WITH SPEED

Coles fast, finger-tip controlled motions provide an infinite range of speeds from zero to maximum. Faster, smoother, safer operation with maximum handling economy is obtained by simple operation of the accelerator pedal.

Designed, manufactured and marketed by:—

STEELS ENGINEERING PRODUCTS LIMITED,
Sunderland, England SALES AND SERVICE :
London, Birmingham, Manchester, Newcastle and Glasgow



EFFORTLESS TRAVEL

Coles Cranes move fast on the road and are designed for swift, easy movement from job to job, under all operating conditions ; built specially to withstand the heavy stresses and shock loadings unavoidable on Crane duties. Our road travel experience is greater than any other European Manufacturer, let us pass this on to you.

FULL-CIRCLE SLEWING

The operator, situated on the front of the full-circle-slewing superstructure, can place the hook in any position within a circle, having a radius equally the length of the jib ; he can reverse the motion and slew in the opposite direction without limit.

98%
Area served by crane from standing position 5606·55 sq. ft.
A Coles full circle slewing crane operating with a 60' jib can efficiently serve an area of over 5,000 sq. ft.

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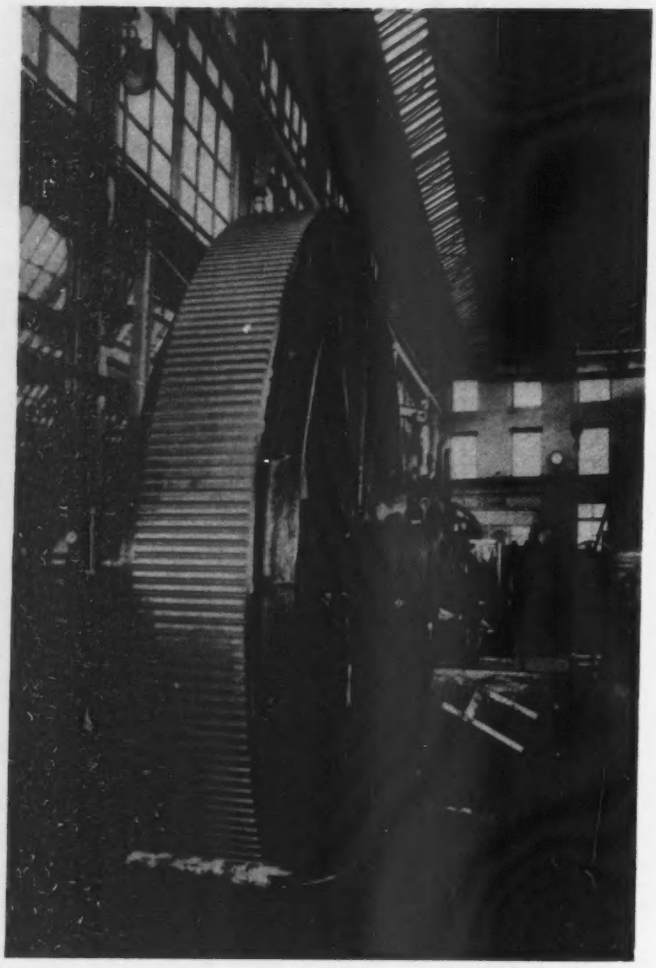

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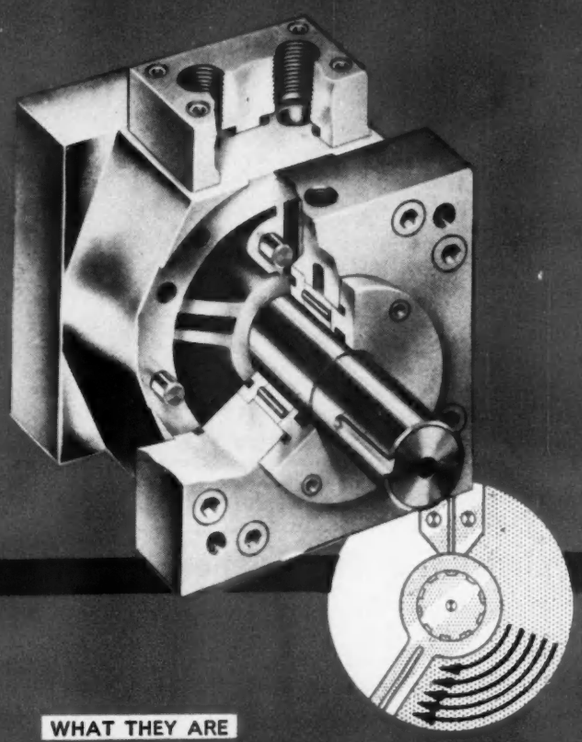
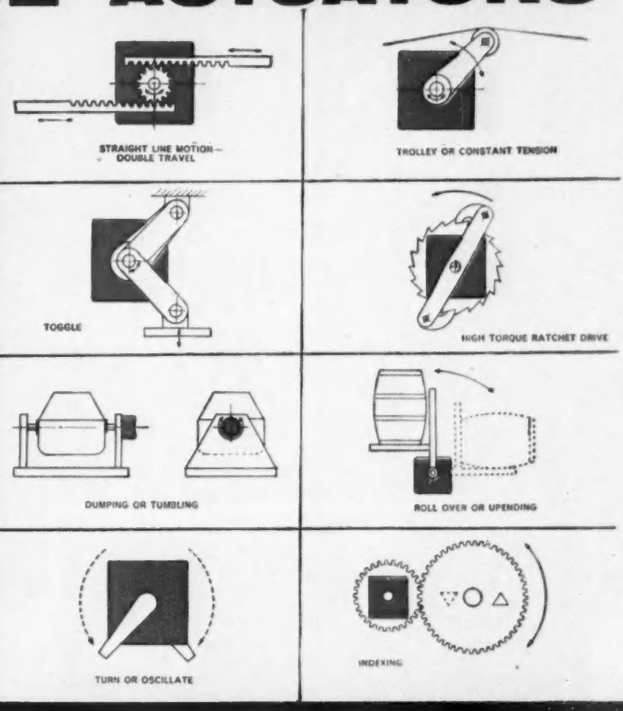




WHAT THEY ARE

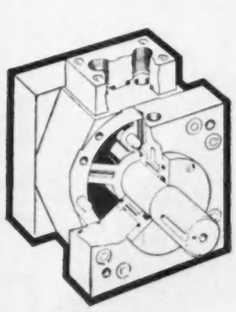
Keelavite/Rotac units are operated hydraulically at low to medium pressures, developing instant torque in either direction. For single vane units the motion is limited to a maximum arc of 280 degrees by the fixed shoe within the cylinder. Power can be doubled by the use of two vanes. In this case the arc of travel is 100 degrees.

WHY THEY ARE BETTER

Torque actuators provide high power in a small space with simple mountings. They can replace other types of actuators, such as cylinders, which require complicated linkage to perform the same functions. In hydraulic systems torque actuators are an ideal solution to many complex mechanical problems.

TYPICAL USES

Opening and closing valves.
Opening and closing doors.
Automation and machine tool uses including:
indexing, feeding, transferring, clamping, locating, turning over.
Freight car tippling.
Crane boom operation.
Pipe and tube bending.
Fatigue test applications.
Foundry equipment.
Materials handling and control of movement on conveyors.



1. *Choice of mountings for fixing at any angle in any position.*
2. *Effective sealing means no oil leak therefore positive control of shaft rotation.*
3. *Working mechanism fully sealed from dirt.*

Keelavite/Rotac rotary actuators are manufactured in the United Kingdom

under licence from the XLO *Corporation*

THE RECOGNISED AUTHORITY

For full details write to KEELAVITE Hydraulics

KEELAVITE HYDRAULICS LTD
ALLESLEY, COVENTRY TEL: MERIDEN 441

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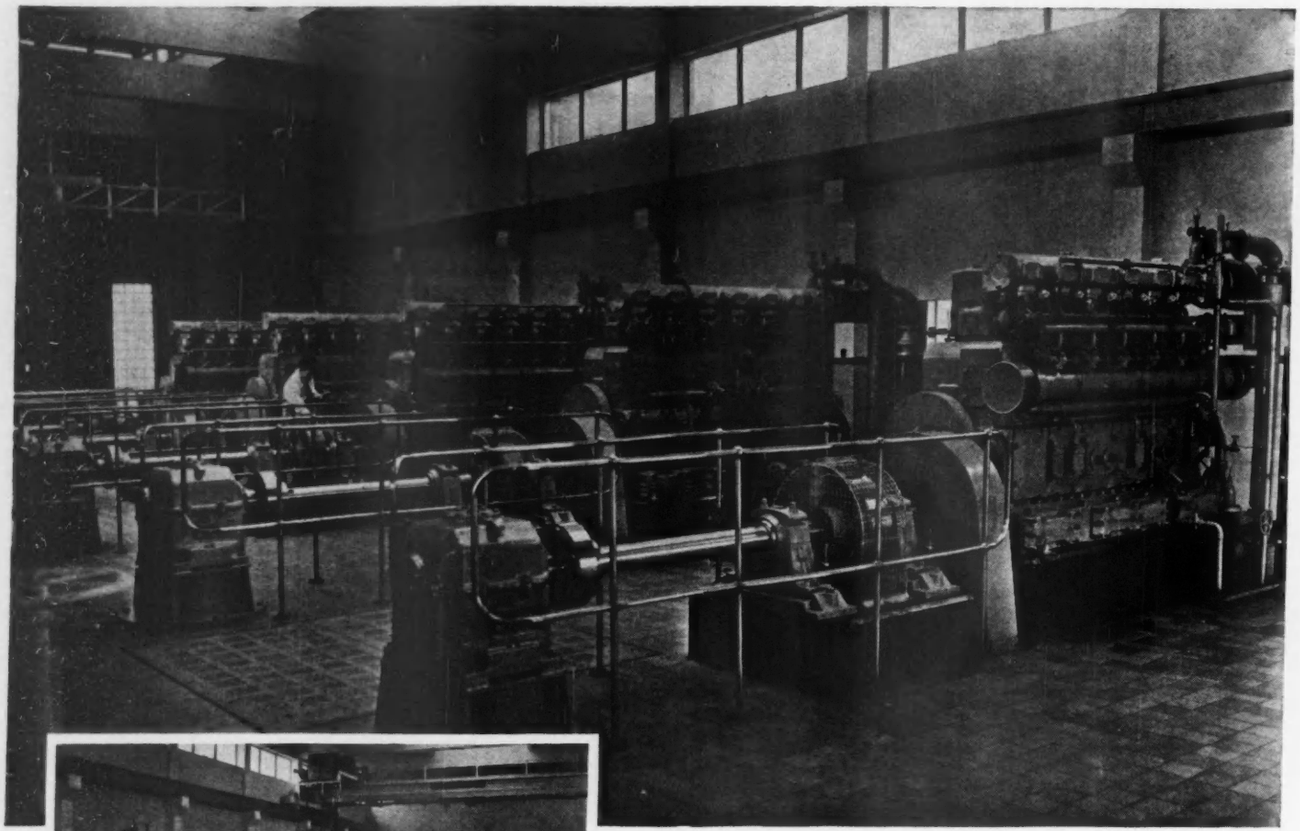

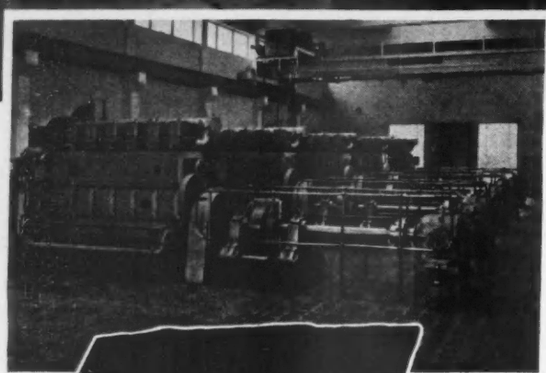

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The pumping station houses five National engines each driving through David Brown speed increasing gears, a vertical shaft single stage multiflow pump rated at 20 m.g.d. supplied by W. H. Allen, Sons & Co. Ltd.

Three of the engines are designed to run on a mixture of sludge gas and diesel oil and two as straight diesel engines. All five engines have a continuous rating of 231 b.h.p. at 600 r.p.m.

Details of National Dual-Fuel engines ranging from 156 to 1248 b.h.p. will be supplied on request.

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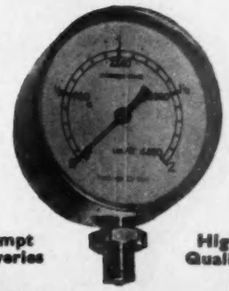

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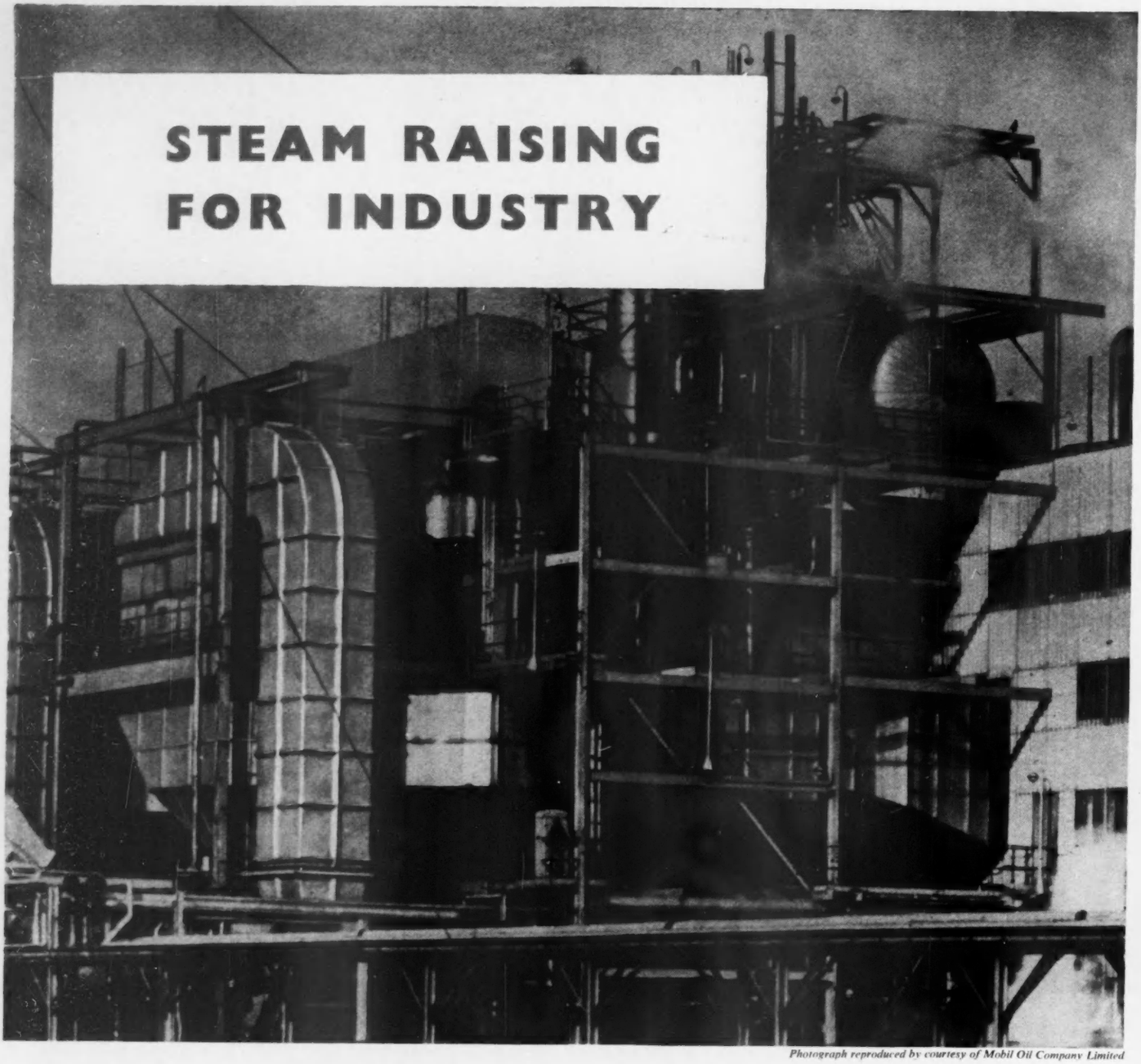

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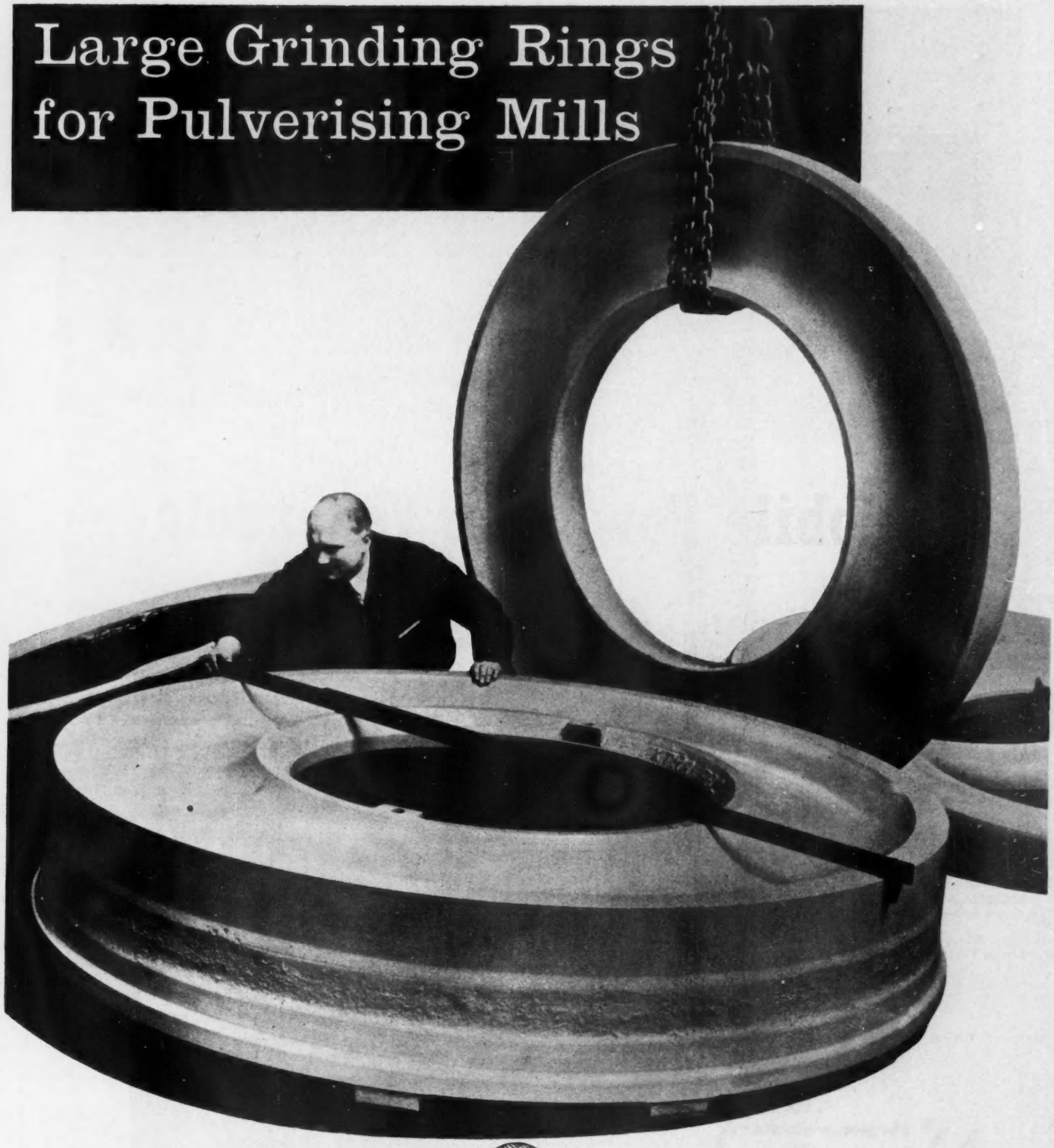

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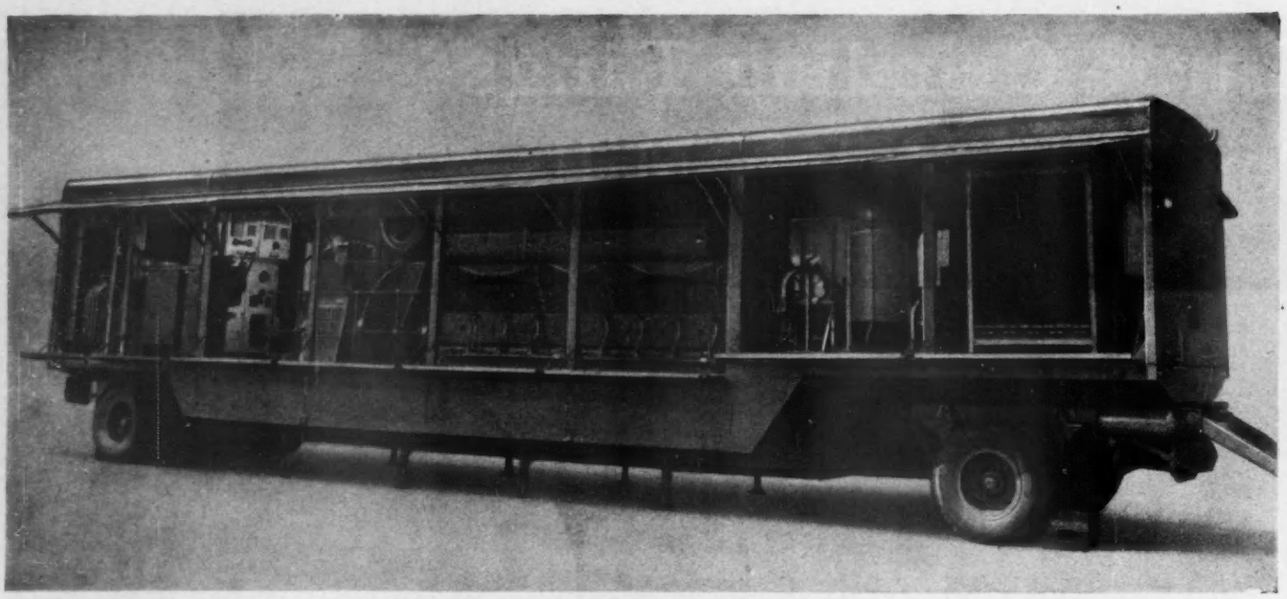
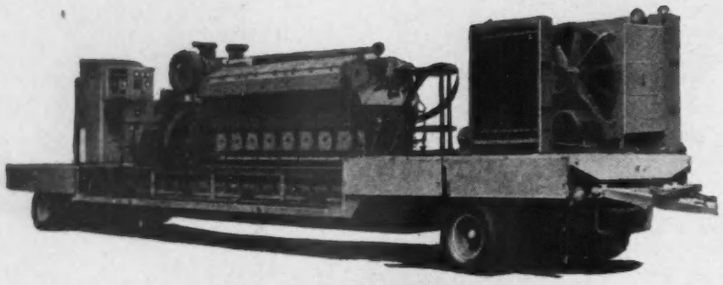
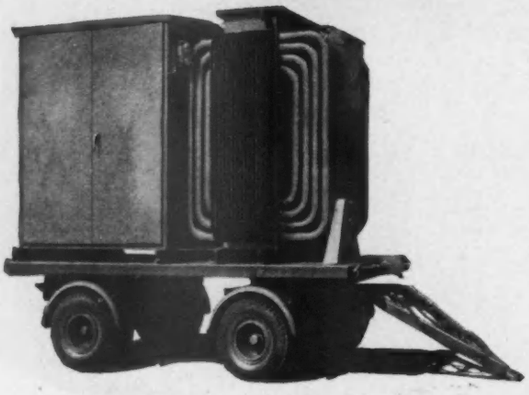


Mobile Power for Venezuela





Four of the largest mobile generating sets ever constructed have recently been completed by Mirrlees, Bickerton & Day Ltd. for La Corporacion Venezolana de Fomento. Designed for use in townships and works where the local permanent power station is not sufficient to meet the demand, these diesel generators are capable of providing power for an average town.

The sets are made up of two trailers; one for generation the other for transformer duties. The power unit consists basically of a Mirrlees JVS.16 turbo-charged diesel engine with a continuous site rating at 900 r.p.m. of 1727 b.h p. This drives a Brush 1200 kW generator, installed complete with switchgear and control panel.

The other trailer carries a Brush 1500 kVA Transformer which is capable of converting the full alternator output from 2,400 to 13,800 volts.

Mirrlees diesel power once again leads the way.

* **The photographs show:—**

TOP: *Complete Generation Trailer. Weight approx. 52 tons, 50 ft. long, 10 ft. wide, 12 ft. high.*

CENTRE: *Mirrlees JVS.16 diesel engine and Brush generator in process of being fitted on Generation Trailer.*

BOTTOM: *Transformer Trailer. Weight approx. 10 tons. 12 ft. 6 ins. long, 7 ft. 6 ins. wide, 12 ft. high.*

Mirrlees

diesels

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Telephone: Stepping Hill 1000 (15 lines) *A member of the Hawker Siddeley Group* *Telegrams:* "Mirrlees, Telex, Manchester"

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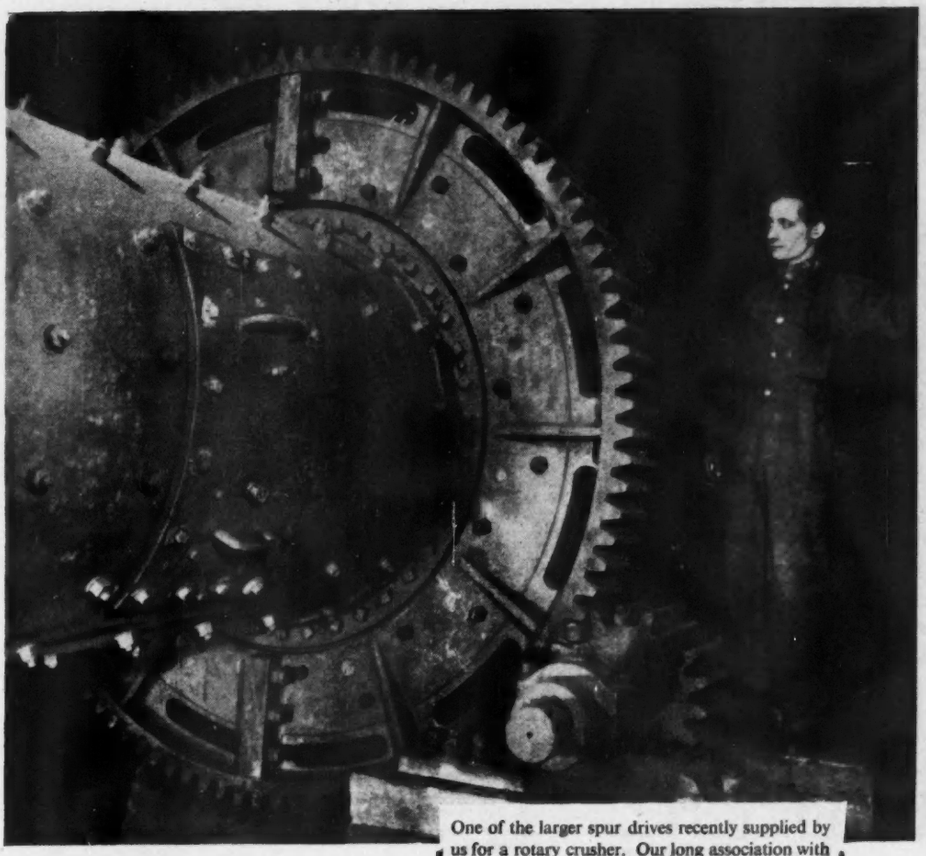

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One of the larger spur drives recently supplied by us for a rotary crusher. Our long association with the heavy industries is one more reason for specifying:— "Gears by Aurora". For all applications, large or small, send us your enquiries—our long experience is at your service.

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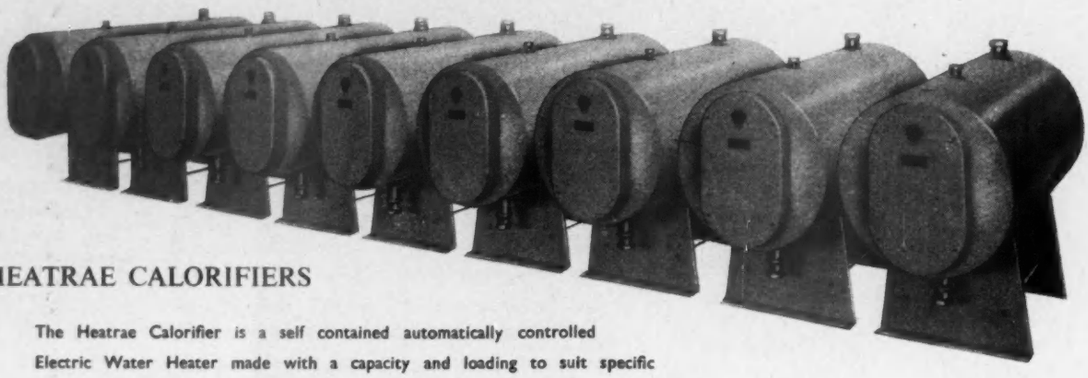

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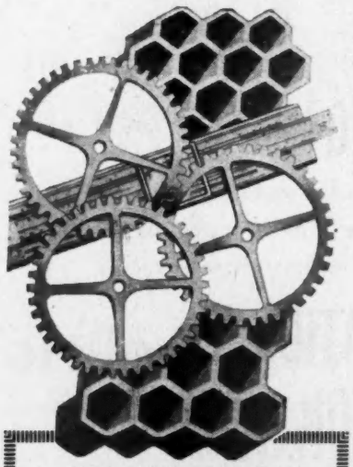

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Monday, February 22
Vacuum melted materials
Magnesium alloys Stainless steels

Tuesday, February 23
Beryllium Powder metallurgy
Reinforced plastics Rubber in engineering Plastics for high temperatures

Wednesday, February 24
Developments in fluid power
Centrifugal castings Cast iron as an engineering material

Thursday, February 25
Seals Pumps Standards in design in Britain, Germany and Russia

Friday, February 26
The case for industrial design
Industrial design in engineering
Photo-elasticity in design
High pressure hydraulics

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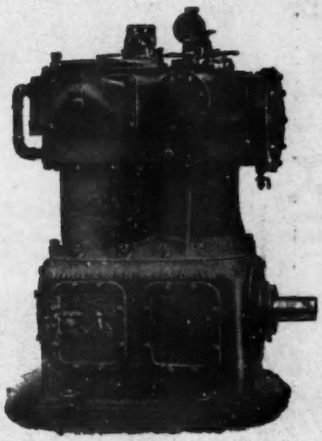

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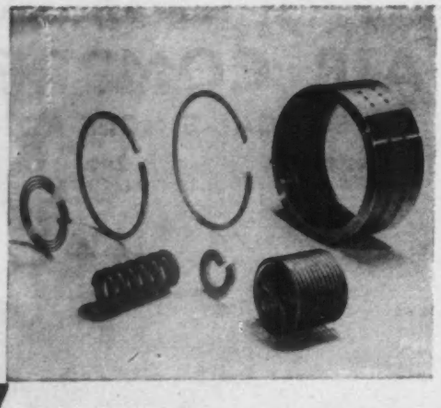

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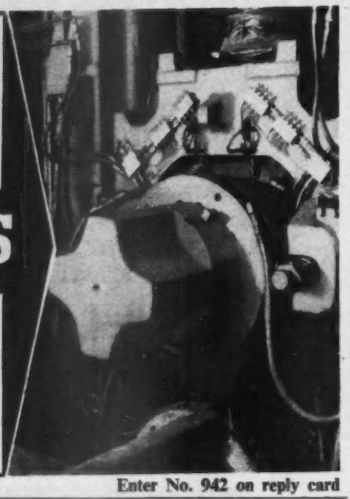

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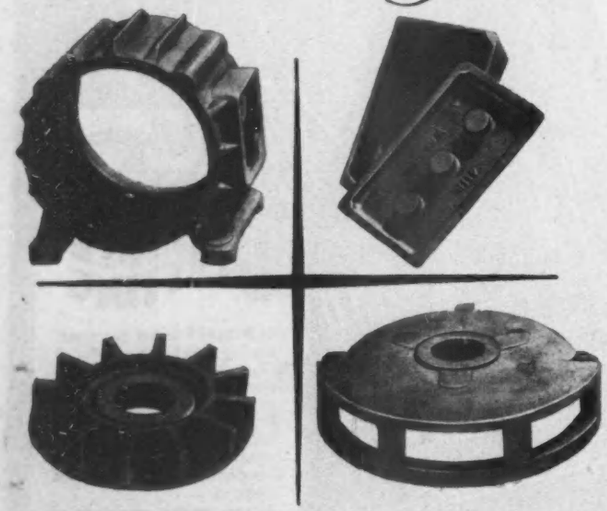

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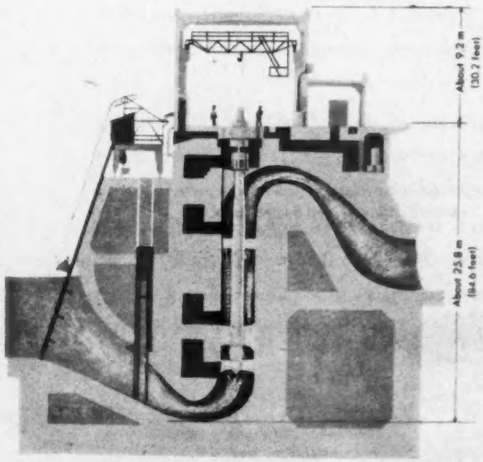

. . . will be made possible through the three (3) huge Vertical Type Adjustable Blade Axial Flow Pumps built by Hitachi for East Pakistan. Each pump has a motor output of 2,800 kW and a 2,700 mm impeller diameter. To be installed in East Pakistan for pumping water from the Ganges River during the dry season for irrigation purposes, the pump is only part of the equipment for the huge Pump Station being supplied by Hitachi, including the screen and gate on the suction side, a trash rack crane and an electric overhead crane.

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Type-Porm	Vertical Shaft Direct Motor Driven Adjustable Blade Axial Flow Pump
No. of main Pumps	3
Unit Capacity	1,700 m³/min (60,040 ft.³/min)
Total Head	8.25 m (27')
Impeller Diameter	2,700 mm (8.86')
Motor Output	2,800 kW 200 rpm (Umbrella-type Vertical Synchronous Motor)

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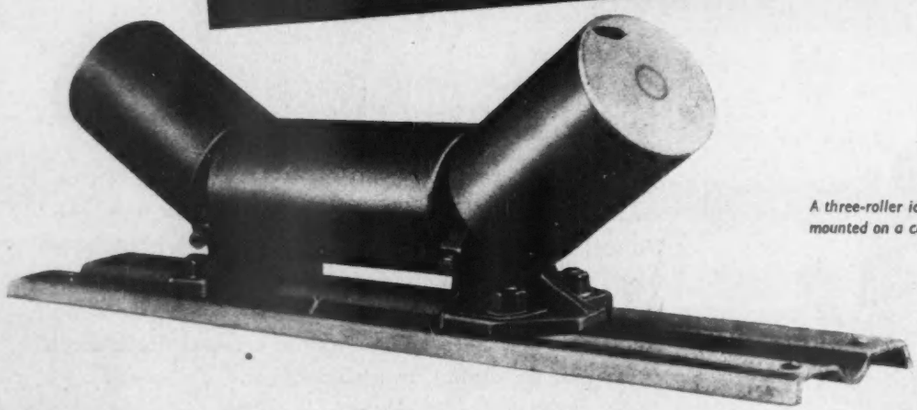

A three-roller idler mounted on a corrugated idler-board.

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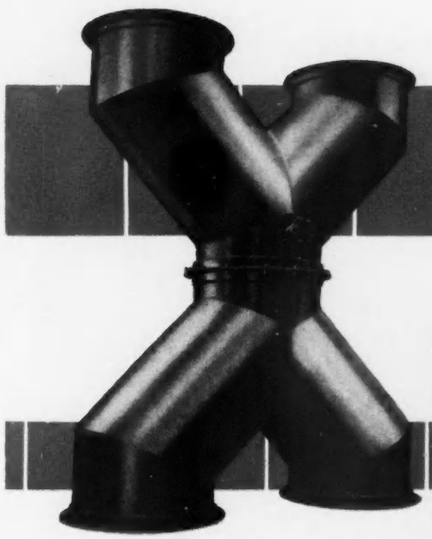

Four-way Branch Pipe

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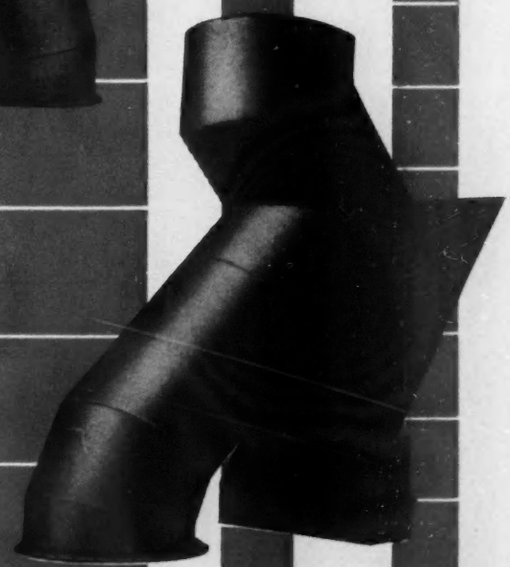

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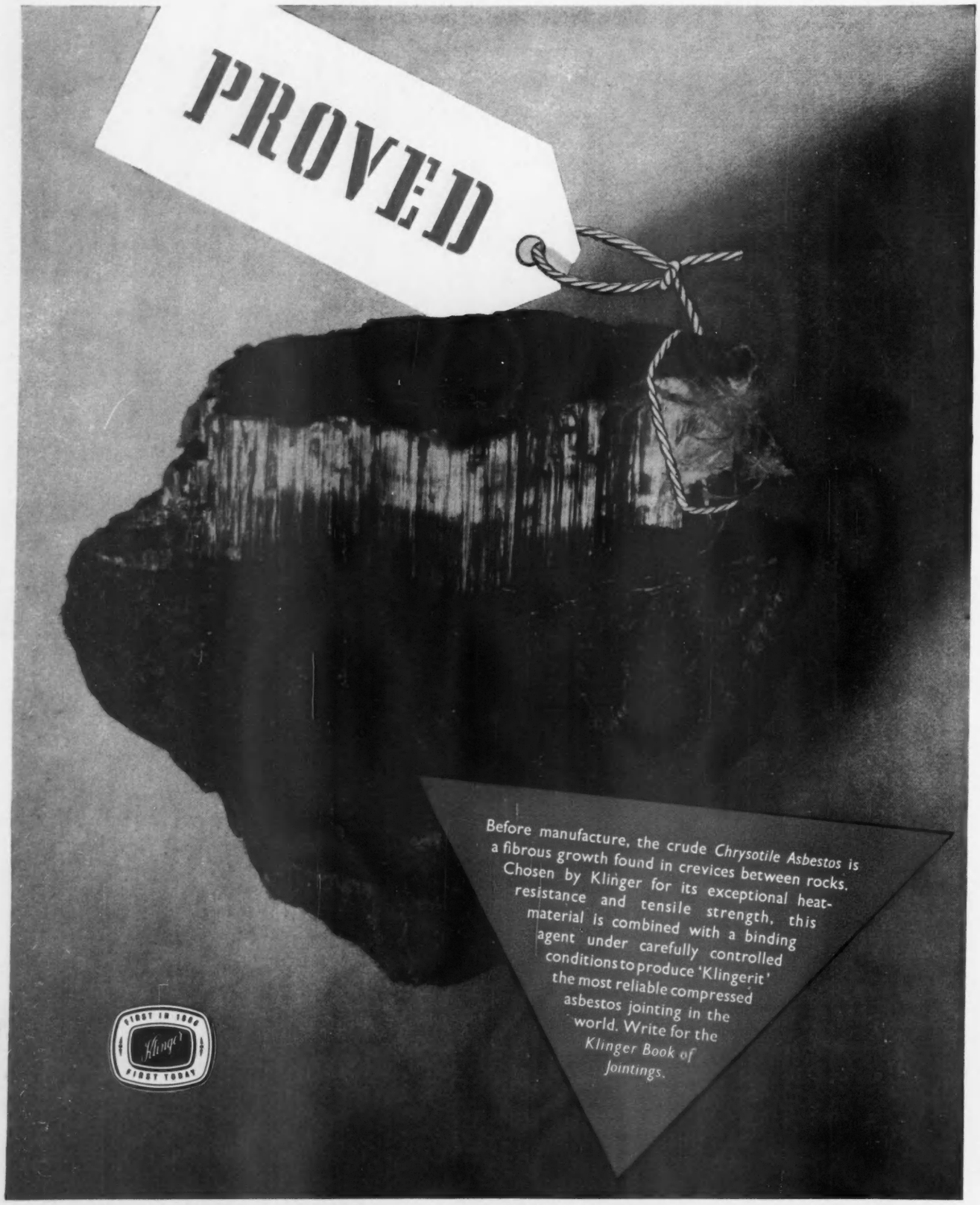
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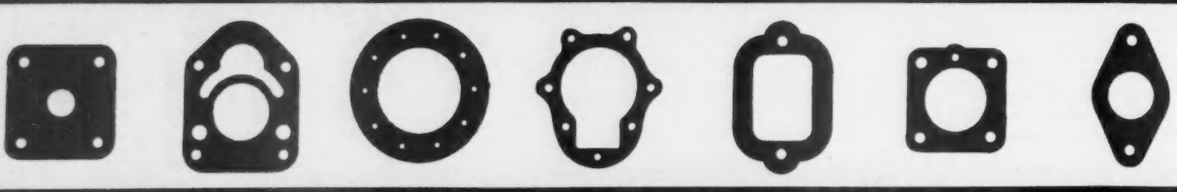

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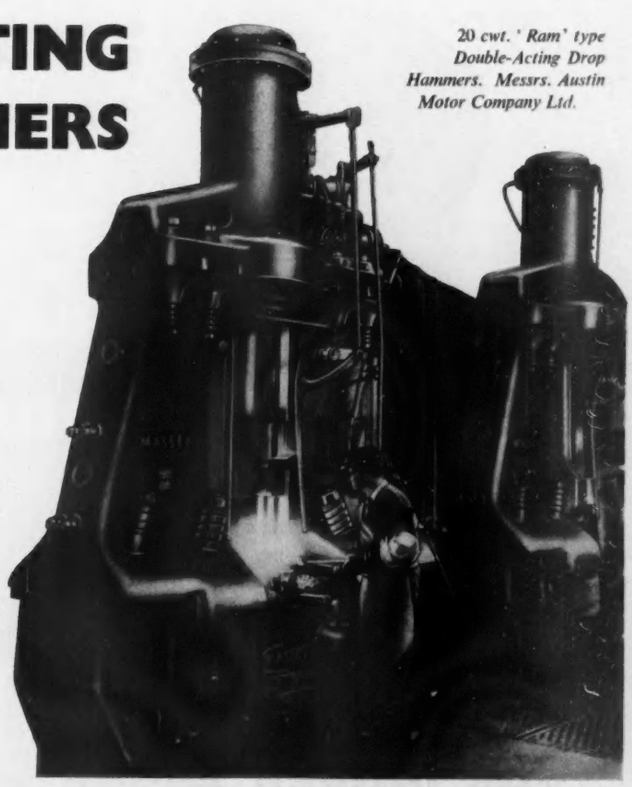

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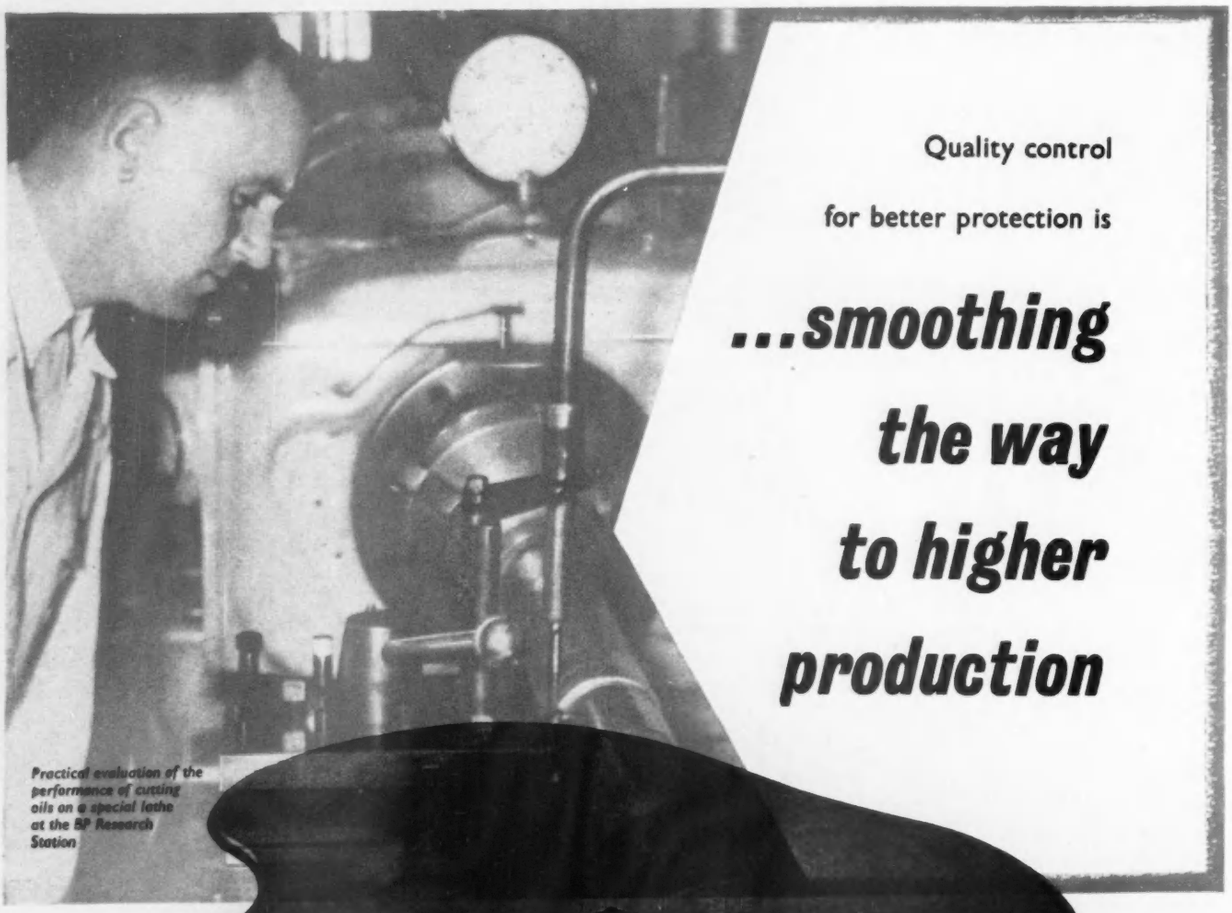

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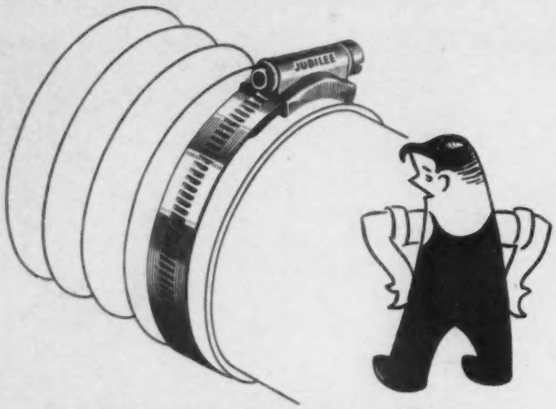

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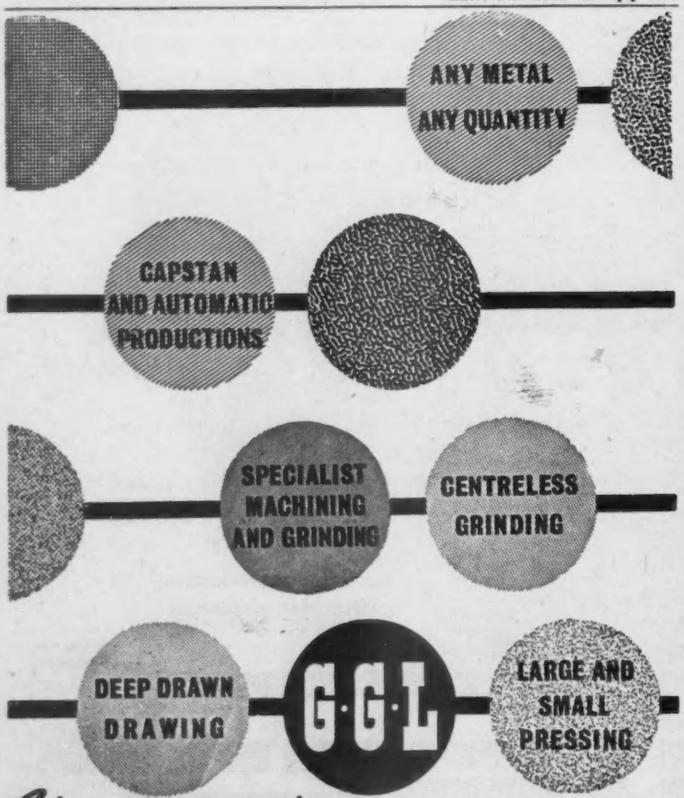

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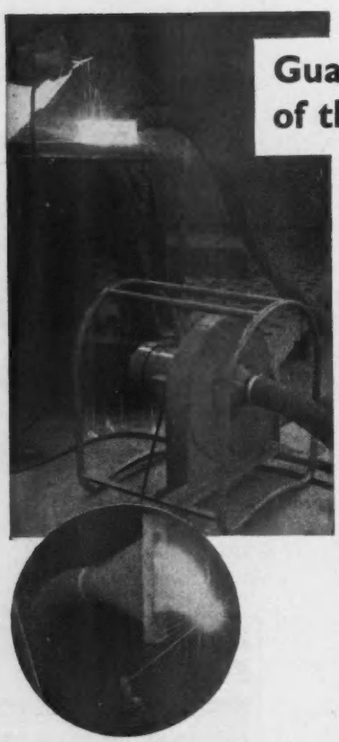

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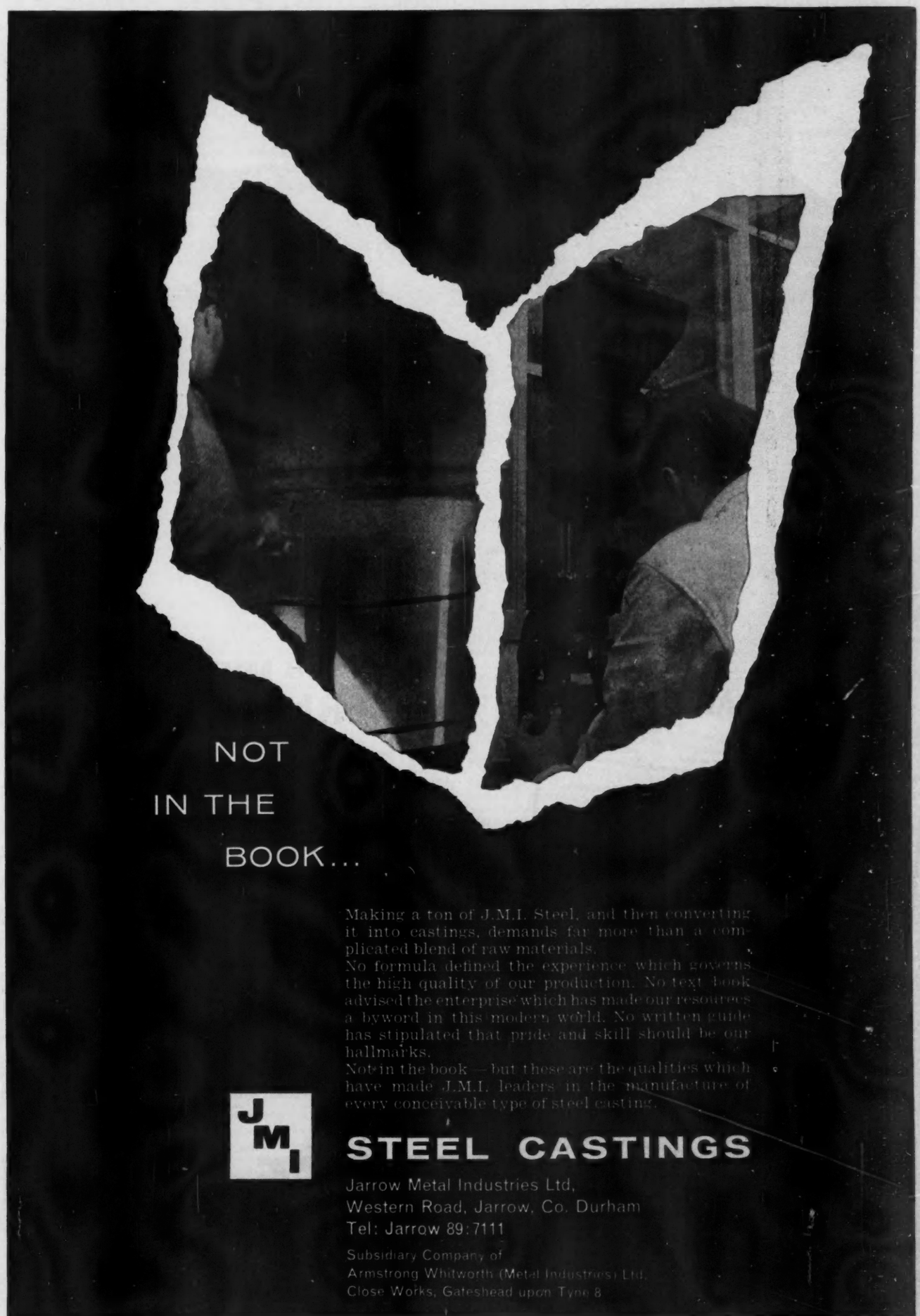
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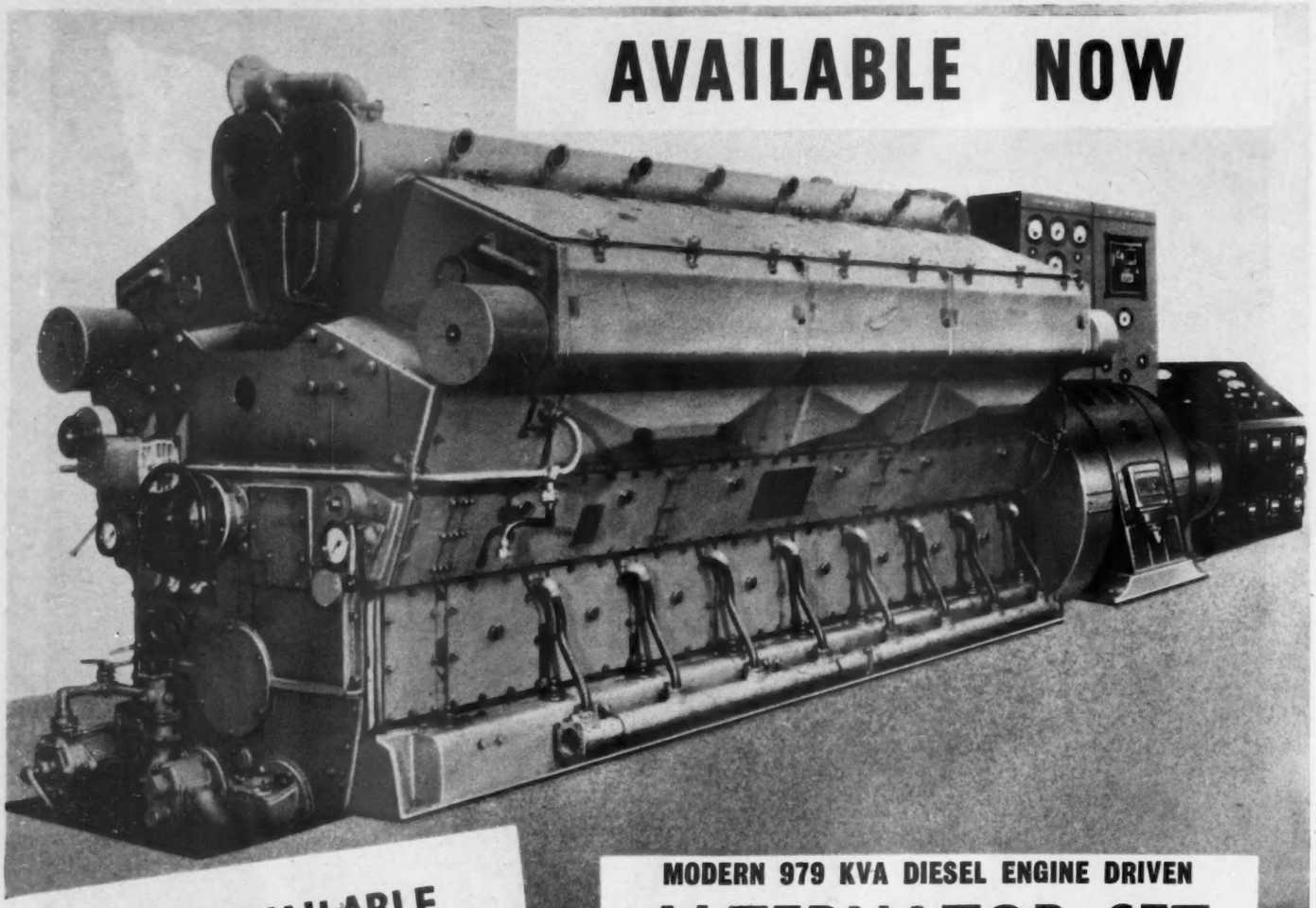

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240kVA, 400/440 volts, 3-phase, 50 cycles, 4-wire DIESEL ENGINE DRIVEN ALTERNATOR SET incorporating 300 h.p. vertical 7-cylinder engine by **Mirrlees Bickerton & Day,** type ULB.7. Direct-coupled at 600 r.p.m. to alternator by **Metropolitan-Vickers,** with exciter. Set complete with standard ancillaries and switchgear.

234kVA, 400/440 volts, 3-phase, 50 cycles, 4-wire DIESEL ENGINE DRIVEN ALTERNATOR SET incorporating 269 h.p. vertical 8-cylinder engine by **Mirrlees Bickerton & Day,** type UA.8. Direct-coupled at 500 r.p.m. to alternator by **Metropolitan-Vickers,** with exciter. Set complete with standard ancillaries and switchgear.

225kVA, 380/420 volts, 3-phase, 50 cycles, 4-wire DIESEL ENGINE DRIVEN ALTERNATOR SET incorporating 262 h.p. vertical 5-cylinder engine by **Mirrlees Bickerton & Day,** type TL.5. Direct-coupled at 600 r.p.m. to alternator by **Brush Electrical,** with exciter. Set complete with standard ancillaries and switchgear.

180kVA, 400/440 volts, 3-phase, 50 cycles, 4-wire DIESEL ENGINE DRIVEN ALTERNATOR SET incorporating 210 h.p. vertical 3-cylinder engine by **Mirrlees Bickerton & Day,** type J.3. Direct-coupled at 750 r.p.m. to alternator by **Brush Electrical,** with exciter. Set complete with standard ancillaries and switchgear.

110kVA, 400/440 volts, 3-phase, 50 cycles, 4-wire DIESEL ENGINE DRIVEN ALTERNATOR SET incorporating 130 h.p. vertical 3-cylinder engine by **Mirrlees Bickerton & Day,** type ULB.3. Direct-coupled at 600 r.p.m. to alternator by **British Thomson-Houston,** with exciter. Set complete with standard ancillaries and switchgear.

500kW, 400/440 volts, 3-phase, 50 cycles, 4-wire DIESEL ENGINE DRIVEN ALTERNATOR SET incorporating 875 h.p. 7-cylinder engine by **Belliss & Morcom,** Series 22A. Direct-coupled at 375 r.p.m. to alternator by **Lancashire Dynamo Co.,** with exciter. Set complete with standard ancillaries and switchgear.

SIX 330kVA, 400/440 volts, 3-phase, 50 cycles, 4-wire DIESEL ENGINE DRIVEN ALTERNATOR SETS, each incorporating 371 h.p. 12-cylinder engine by **Ruston Paxman,** type 12RPH2. Direct-coupled at 1000 r.p.m. to alternator by **British Thomson-Houston,** with exciter. Each set complete with standard ancillaries and switchgear. There are also available for each set **English Electric** distribution boards and a quantity of cabling.

THE 600 GROUP OF COMPANIES

GEORGE COHEN

SONS AND COMPANY LIMITED

WOOD LANE, LONDON, W.12
Telephone: Shepherds Bush 2070
Telegrams: Omniplant, Telex, London

STANNINGLEY, Nr. LEEDS
Telephone: Pudsey 2241
Telegrams: Coborn, Leeds

And at Kingsbury (Nr. Tamworth), Manchester, Glasgow, Bath, Swansea, Newcastle-on-Tyne, Belfast, Sheffield, Southampton.

Enter No. 1041 on reply card

CLASSIFIED ADVERTISEMENTS

PUBLIC APPOINTMENTS · SITUATIONS VACANT · TENDERS · EDUCATIONAL · BUSINESSES and PREMISES · BUSINESS OPPORTUNITIES PATENTS · MISCELLANEOUS · AGENCIES · DIRECTORS · PARTNERSHIPS

Lineage Rate. 4/6 per line of approximately 6 words. **Minimum 18/–.** **Inch Rate.** 54/– per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £29 10s. ½-page £54. Full page £100.

FOR SALE · MACHINERY, etc., WANTED · AUCTION SALES · SITUATIONS WANTED · SUB-CONTRACTING · DESIGN SERVICES · FOR HIRE

Lineage Rate. 4/– per line of approximately 6 words. **Minimum 16/–.** **Inch Rate.** 48/– per single column inch and pro rata. 12 lines to 1 inch.

There are reduced rates (i.e., not on a pro rata basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an Illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/– which includes forwarding of replies.

Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.

Advertisements for publication should be addressed to:—**Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**

Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

ROYAL MILITARY COLLEGE OF SCIENCE, SHRIVENHAM, BERKS

LECTURERS

Royal Military College of Science, Shrivenham, Berks, requires :

(a) Male LECTURER in PHYSICS (Ref. A.67/OA).

(b) TWO Male LECTURERS or SENIOR LECTURERS in MECHANICAL ENGINEERING (Ref. C.135/OA).

Teaching is at University level.

Qualifications : For (a) First or second class Honours degree in Physics, preferably with teaching and/or research experience. Successful candidate to lecture to degree courses and possibly to specialised courses, and assist with laboratory classes. Also expected to engage in research in field of nuclear physics, radiation physics, or solid state physics. Work suitable for open publication and submission for higher degree. For (b) First or second class Honours degree in Mechanical Engineering together with background of workshop practice. Successful candidates required to lecture to students taking all parts of London External B.Sc. (Eng.) examinations, to organise related laboratory and course work and be prepared to teach at post-graduate level thermodynamics associated with rocket propulsion or internal combustion engines or nuclear power generation and to carry out research individually or as part of team. Salary : Senior Lecturer, £1166–£1420 ; Lecturer, £615–£1120. Starting pay may be above minimum ; credit for post-graduate experience and National Service. Superannuable with good prospect of permanency. Quarters in residential officers' mess for single men. Possibility of houses for married men. Particulars and forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting appropriate reference. Closing date 4 March, 1960. E8890

BRADFORD INSTITUTE OF TECHNOLOGY

Principal : E. G. EDWARDS, Ph.D., B.Sc., F.R.I.C.

SENIOR LECTURER IN MECHANICAL ENGINEERING

Applications are invited for the post of SENIOR LECTURER IN MECHANICAL ENGINEERING.

Candidates should be well-qualified and industrial and research experience would be a recommendation. The successful candidates will be required to teach one or more subjects to Honours Degree standard. They will be encouraged to undertake research and adequate facilities will be available.

Salary scale : £1550–£1750 per annum.

Previous industrial or research experience at a suitable level may be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Registrar, Bradford Institute of Technology, Bradford, 7.

HENRY PATTEN,
E8910 Clerk to the Governors.

HARRIS COLLEGE, PRESTON

Principal : H. WILKINSON, M.Sc. Tech., Ph.D., A.Inst.P.

HEADSHIP OF THE MECHANICAL ENGINEERING DEPARTMENT

Applications are invited for the HEADSHIP OF THE MECHANICAL ENGINEERING DEPARTMENT. Applicants must have high academic and professional qualifications in Mechanical Engineering. Teaching experience in a similar establishment is essential.

The vacancy arises through the retirement of the present Head and the salary will be in accordance with the Burnham Scale for Heads of Departments, Grade IV.

Fuller information and forms of application may be obtained from the Principal to whom they should be returned within 14 days of the appearance of this advertisement.

W. R. TUSON,
E8918 Clerk to the Harris Council.

PUBLIC APPOINTMENTS

BRADFORD INSTITUTE OF TECHNOLOGY

Principal : E. G. EDWARDS, Ph.D., B.Sc., F.R.I.C.

Applications are invited for the position of :

PRINCIPAL LECTURER IN MECHANICAL ENGINEERING

Candidates should be qualified to teach to final degree standard, preferably in Thermodynamics and Mechanics of Fluids and should have had adequate industrial experience.

The successful candidate will be expected to assist the Head of the Department with the administrative work of the Department and will be encouraged to develop industrial contacts.

Salary Scale : £1750 to £1900 per annum.

Previous industrial and research experience, at a suitable level, will be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Registrar, Bradford Institute of Technology, Bradford, 7.

HENRY PATTEN,
E8927 Clerk to the Governors.

CITY OF WAKEFIELD

TECHNICAL AND ART COLLEGE

ASSISTANT

Applications are invited from suitably qualified persons for the following full time appointment in the Department of Engineering and Science, to commence 1st September, 1960.

ASSISTANT, Grade B, to teach Workshop Practice and take charge of the Engineering Workshops. Applicants should be good craftsmen with sound practical experience. Possession of Final City and Guilds Certificate in Machine Shop Engineering and previous teaching experience would be additional recommendations.

Forms of application and further particulars may be obtained from the undersigned on receipt of a stamped, addressed foolscap envelope.

C. L. BERRY,
Director of Education.

Education Department,
27, King Street,
Wakefield. E8920

UNIVERSITY OF LEEDS

DEPARTMENT OF CIVIL ENGINEERING

TWO LECTURESHIPS

Applications are invited for TWO LECTURESHIPS in Civil Engineering, at salaries on the scale £900 by £50 to £1350 (efficiency bar) by £75 to £1650 a year. Candidates should have had some practical experience and preference will be given to those with a special interest in at least one of the following subjects : Hydraulics, Surveying, Heating and Ventilation, Steelwork Design. Applications (three copies) stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, The University, Leeds, 2 (from whom further particulars may be obtained) not later than 1st April, 1960. E8887

UNIVERSITY COLLEGE, DUBLIN

DEPARTMENT OF CIVIL ENGINEERING

RESEARCH ASSISTANT

Applications are invited for a temporary post as RESEARCH ASSISTANT in Civil Engineering. Salary £900 per annum.

Candidates should have a good Honours degree and experience in design and construction. Special qualifications in Soil Mechanics would be an advantage.

Applications accompanied by the names of two referees to be sent to the Secretary, Civil Engineering Department, University College, Upper Merrion Street, Dublin, on or before 11th March, 1960, from whom further particulars may be obtained. E8899

PUBLIC APPOINTMENTS

UNIVERSITY OF ADELAIDE

SENIOR LECTURER IN CIVIL ENGINEERING

Applications are invited for the above-mentioned appointment. The University seeks candidates with special interest in Hydraulics.

Salary scale : £A2100 by £A80 to £A2500, with superannuation on the F.S.S.U. basis.

Copies of the general conditions of appointment of Senior Lecturers in the University may be had on application to the Secretary, Association of Universities of the British Commonwealth, 36, Gordon Square London, W.C.1, or to the Registrar ; the Calendar of the University may be seen in the Library of any University which is a member of the A.U.B.C. ; housing help is available ; and any further information desired will be supplied on request.

Applications, in duplicate and giving the information listed in the general conditions of appointment, should reach the Registrar, The University of Adelaide, Adelaide, South Australia, not later than March 21, 1960. E8911

UNIVERSITY OF LONDON KING'S COLLEGE

LECTURER OR ASSISTANT LECTURER IN CIVIL ENGINEERING

Applications are invited for this post. Candidates should have a good Honours Degree, some experience of teaching and/or research and professional experience is also desirable. The salary for an Assistant Lecturer is on the scale £700 by £50 per annum to £850, and for a Lecturer £900 by £50 per annum to £1350, then by £75 per annum to £1650. The starting point will be according to qualifications and experience. A London allowance of £60, family allowances and F.S.S.U. benefits will also be payable.

Conditions of appointment and application forms may be obtained from the Registrar, King's College, London, Strand, W.C.2, completed forms must reach him by 16th March. E8905

UNIVERSITY OF SOUTHAMPTON

READER IN STRUCTURAL ENGINEERING

Applications are invited for the post of READER IN STRUCTURAL ENGINEERING, newly established in the Department of Civil Engineering, with the support of the Institution of Structural Engineers. Candidates should have considerable experience in structural engineering research and should be capable of promoting a school of research in their own specialities. Salary Scale : £1450 by £75 to £2125 by £25 to £2150. Initial salary will depend on qualifications and experience. Further particulars should be obtained from the Secretary and Registrar to whom applications (14 copies from United Kingdom applicants) should be sent not later than 15 March, 1960. E8943

CITY OF BRADFORD WATER DEPARTMENT

APPOINTMENT OF ENGINEERING STAFF

Applications are invited for three superannuable appointments :

(a) TWO SENIOR ENGINEERING ASSISTANTS, Grade A.P.T. V (£1220–£1375), and

(b) ONE MECHANICAL ENGINEERING ASSISTANT, Grade A.P.T. IV (£1065–£1220).

Candidates for appointments (a) must be Corporate Members of the Institution of Civil Engineers, and for appointment (b) must be Corporate Members of the Institutions of Mechanical, Civil or Electrical Engineers.

Candidates for appointments (a) should have a wide experience in water supply. They will be required for work in connection with the maintenance of the water undertaking, and particularly in the design and construction of large aqueduct pipelines, rapid gravity filtration plant, reservoir works, boosters, etc. Appointment (b) covers work on the maintenance and general upkeep of transport, mechanical and electrical plant.

Applications, stating age, training, professional qualifications and experience, together with the names of two referees, must reach the undersigned by the 5th March, 1960.

HENRY PATTEN,
Town Hall, Town Clerk.
Bradford, 1. E8874

PUBLIC APPOINTMENTS

CITY OF LEEDS

WATERWORKS DEPARTMENT

APPOINTMENT OF STAFF

Applications are invited for the following appointments :

(a) ENGINEERING ASSISTANT (New Works, J.N.C. Scale "B." Salary within the range of £1320–£1485.

(b) ENGINEERING ASSISTANT—A.P.T. V. £1220–£1375.

(c) ENGINEERING ASSISTANT—A.P.T. IV. £1065–£1220.

(d) SENIOR DRAUGHTSMAN—A.P.T. II. £765–£880.

(e) DRAUGHTSMAN—A.P.T. I. £610–£765.

Applicants for post (a) must be Corporate Members of the Institution of Civil Engineers and should have experience in the design and construction of Impounding Reservoir Schemes.

Applicants for posts (b) and (c) must be Corporate Members of the Institution of Civil Engineers Experience with a Water Undertaking and/or in the design and construction of Impounding Reservoir Schemes will be an advantage. For post (b) experience in the design and installation of pumping plants is desirable.

Applicants for post (d) must be neat draughtsmen and have experience in Civil Engineering Drawings. Experience with a Water Undertaking will be an advantage.

Superannuation payable. Medical examination.

Applications, on forms obtainable from the undersigned, should be delivered not later than 12 noon on Tuesday, 1st March, 1960, endorsed with the description of the post applied for.

Canvassing disqualifies.

KENNETH L. FORSTER,
General Manager and Engineer.

Waterworks Department,
Civic Hall,
Leeds, 1.
4th February, 1960. E8860

MINISTRY OF LABOUR

BUILDING RESEARCH STATION (D.S.I.R.), GARSTON, WATFORD, HERTS

ELECTRICAL ENGINEERS

ELECTRICAL ENGINEERS required at Building Research Station (D.S.I.R.), Garston, Watford, Herts, for following duties : (a) Research connected with electrical service installations in all types of building. (b) Study of methods for electrification of plant and equipment used on building sites including control systems. (c) Development of methods of measurement or data recording by electrical means in connection with building operations or processes. Post (1) Ref. D104/OA at Basic Grade Professional level for which candidates should be Corporate members of I.E.E., or if under 28, Graduate members. Honours degree or Dip. Tech. desirable, research or development or electronics experience an advantage. Starting salary in age range 25–34 : £780–£1065. Maximum £1220. Post (2) Ref. D105/OA Experimental Officer (age 26 or over), requiring H.N.C. or H.N.D. Electrical Engineering qualifications, and at least 5 years' experience in design, development or research work. Salary (according to experience) in range £984–£1166. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting appropriate reference. Closing date 18 March, 1960. E8940

SOUTH EASTERN GAS BOARD

TECHNICAL ASSISTANT MECHANICAL DEPARTMENT DOVER WORKS

Applicants should have had practical experience in Workshops and of the maintenance of mechanical plant, and should have reached Higher National Certificate standard in mechanical engineering.

Salary within ranges £733–£813 p.a., £773–£853 p.a., or £827–£927 p.a., according to qualifications and experience.

Applications in writing, quoting reference V14/1143 and giving full details, should be sent to the Personnel Manager, South Eastern Gas Board, Katharine Street, Croydon, within seven days. E8913

Classified Advts. continued on page 106

PUBLIC APPOINTMENTS

CITY OF LEICESTER

CITY SURVEYOR'S DEPARTMENT

A vacancy has arisen for an

ASSISTANT HEATING AND VENTILATING ENGINEER

who will be afforded the opportunity of working on the design and installation of the heating and ventilation for the new Civic Centre, the new indoor Swimming Baths and a new Technical College building.

The salary will be within the range £765 to £1070 per annum, subject to age, qualifications and experience. For a fully qualified applicant the maximum would be attained at the age of 28 years.

Housing accommodation can be made available for married officers.

The Local Government Superannuation Acts apply subject to medical examination.

Applicants should be Graduate or Associate Members of the Institution of Heating and Ventilating Engineers. Some knowledge of electrical engineering would be an advantage.

Applications, giving full details of age, qualifications and experience, together with the names of two referees, should be forwarded to the undersigned not later than the 3rd March, 1960.

John L. Beckett, M.I.C.E.,
City Surveyor.

Town Hall,
LEICESTER. E8938

NORTH EAST METROPOLITAN REGIONAL HOSPITAL BOARD

EXPANSION OF ENGINEERS DEPARTMENT

ASSISTANT ENGINEERS (MECHANICAL/HEATING AND VENTILATING)

The Board is engaged in an expanding programme of hospital development and the undermentioned appointments offer to Engineers particularly valuable experience in planning and supervising the installation of large-scale heating and hot water systems, conversion of boilers to oil-firing, ventilation of operating theatres, engineering services and equipment for laundries and kitchens.

Own car may be used for visiting hospitals, &c., for which adequate mileage allowance is paid. Posts pensionable and excellent prospects of promotion. Previous hospital experience is NOT essential. ALL SALARY SCALES NOW BEING REVIEWED.

ASSISTANT ENGINEERS (MECHANICAL/HEATING AND VENTILATING)

Salary according to age and experience, up to a maximum of £1105. Applicants must be Graduate Members of the Institution of Mechanical Engineers; or Graduate Members of the Institution of Heating and Ventilating Engineers, and have passed the Associate Membership examination or hold exempting qualifications. The posts offer opportunities to cover the whole field of heating, ventilating and mechanical engineering in hospitals.

Application forms from Secretary, North East Metropolitan Regional Hospital Board, 40, Eastbourne Terrace, W.2. E8960

AIR MINISTRY

LONDON AND PROVINCES

ENGINEERING DESIGNER DRAUGHTSMEN

Air Ministry Works Designs Branch requires in London and Provinces ENGINEERING DESIGNER DRAUGHTSMEN experienced in preparation of pipework and mechanical and electrical plant layouts. Candidates should have served recognised apprenticeship or had equivalent training and also have had practical experience. O.N.C. an advantage. Financial assistance and time off given for recognised courses of study. Promotion and pension prospects. Five-day week with 18 working days' leave per year initially. Overseas tours for which special allowances granted.

Salary in London ranges from £680 (at age 25) to £900 per annum for men; from £673 to £868 per annum for women. Somewhat lower in Provinces. Commencing salary dependent on age, qualifications and experience.

Applicants, who must be natural born British subjects, should write to Air Ministry, W.G.e, Lacon House, Theobalds Road London, W.C.1, or to any Employment Exchange (quoting Order No. Kings Cross 3743), giving age, details of training, qualifications, full particulars of former posts held, and copies of any testimonials. Candidates selected will normally be interviewed in London and certain expenses reimbursed. P8431

MINISTRY OF LABOUR

TERRY RESEARCH STATION, ABERDEEN

RESEARCH ENGINEERS

TWO RESEARCH ENGINEERS required at Terry Research Station, Aberdeen, in team whose work ranges from fundamental research on heat transfer to development of new processes and equipment for fishing industry. Post A graded Senior Scientific Officer; Post B Scientific Officer. Qualifications: 1st or 2nd Class Honours degree in Engineering (or equivalent) plus (for S.S.O.) at least 3 years' post-graduate experience in refrigeration or allied heat transfer field. For both posts ability to translate research results into sound engineering design is essential. Practical knowledge of refrigeration applications or food processing an advantage. Salary range: S.S.O. (Men) £1200–£1420; S.O. £635–£1120. Forms from Ministry of Labour, Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting C.584/9A. E8889

CIVIL SERVICE COMMISSION

PATENT EXAMINERS AND PATENT OFFICERS

Pensionable posts for men or women for work on the examination of Patent applications. Age at least 21 and under 29 (36 for Examiners), with extension for regular Forces service and Overseas Civil Service. Qualifications: normally First or Second class honours degree in physics, chemistry, engineering or mathematics, or equivalent attainment, or professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E.E., A.R.I.C. London salary (men) £655–£1460; provision for starting pay above minimum. Promotion prospects. Write Civil Service Commission, 17, North Audley Street, London, W.1, for application form, quoting S/128/60, and stating date of birth. E8891

WEST KENT MAIN SEWERAGE BOARD

JUNIOR ENGINEERING ASSISTANTS

Two JUNIOR ENGINEERING ASSISTANTS required, in A.P.T.I. (£610–£765 p.a., plus London weighting). Experience of general engineering drawing office practice is essential. Local Government superannuation.

The Board's District covers 172 square miles; the population exceeds 600,000. Current work includes new main sewers in tunnel and the design and construction of new purification works.

Applications, with full personal details, particulars of education, training and experience, and the names and addresses of two referees to William Howard, B.Sc., M.I.C.E., Engineer to the Board, within ten days of publication of this advertisement.

A. J. W. JEFFERY,
Secretary of the Board.

20, Blyth Road,
Bromley, Kent. E8949

CIVIL SERVICE COMMISSION

CIVIL, STRUCTURAL, AND PUBLIC HEALTH ENGINEERS

Pensionable posts for men and women at least 25 and under 35 on 1st January, 1960 (extension for regular Forces service, Overseas Civil Service, established civil service and temporary Government service as Civil, Structural, or Public Health Engineer). Candidates must have achieved Corporate membership of an appropriate professional Institution, or have passed examinations necessary for attaining such membership. Some posts require qualifications in certain subjects. Starting salary (men, London) from £830 to £1125 according to age. Scale maximum (London) £1300. Promotion prospects. Write Civil Service Commission, 17, North Audley Street, London, W.1, for application form, quoting S/64-66/8. E8939

TENDERS

MADRAS PORT TRUST

FOR THE SUPPLY OF 2400FT. OF SHORE PIPE LINE

The office of the Chief Engineer, Madras Port Trust, Madras, India, invites TENDERS for the following:

TENDER ENQUIRY No. D./3714/59/EP.

For the SUPPLY of 2400ft. of SHORE PIPE LINE, 14 inches i.d., and 4 Nos. LONG RADIUS BENDS with suitable joints, for dredging of Wet Dock.

Specifications, drawings, &c., relative to the above Tender enquiry can only be obtained direct from the Deputy Chief Accounts Officer (Engineering), Chief Engineer's Office, Madras Port Trust, Madras, 1, India, on payment of 15 shillings per Tender set, and is not refundable.

Tenders are to be returned to the Chief Engineer ("C" Warehouse), Madras Port Trust, Madras, India so as to reach him by 15th March, 1960, and not to this office.

Specimen copy of the above enquiry can be seen at Engineering Branch, India Store Department, Bromyard Avenue, Acton, London, W.3, under the following reference: S.4120/59/NSC/ENG.2. E8951

TENDERS

GOVERNMENT OF ANDHRA PRADESH

ELECTRICITY DEPARTMENT

TENDER ENQUIRY NO. APT.44/59—TELENGANA HYDRO THERMAL SCHEME

For the SUPPLY of ONE number WATER TUBE BOILER, 150,000 lb. per hour at 425 p.s.i.g. and 775 deg. Fah. or 900 p.s.i.g. and 925 deg. Fah., with Pumps and Steam Mains required by Andhra Pradesh Government for the Ramagundam Boiler Extensions.

Sealed Tender in duplicate superscribed "Tenders for Supplying of Ramagundam 150,000 lb. per hour boiler Extension of Telengana Hydro Thermal Scheme," will be received by the Government of Andhra Pradesh, Electricity Department, Hyderabad, Deccan, India, up to 2 p.m. on 9th May, 1960, and opened at 3 p.m. on the same date in the presence of such of the Tenderers or their representatives that may be present.

Copies of specifications APT.44/59, covering full particulars of the equipment required, can only be had from the Superintending Engineer (Technical), Government of Andhra Pradesh, Electricity Department, Hyderabad, Deccan, India, on production of a challan for Rs.76.50 n.p. (inclusive of sales tax), i.e. £5 14s. 9d., remitted into the Reserve Bank of India, Madras, or its branches, or Treasuries in Andhra Pradesh under the head "XLVI—Miscellaneous Sales of Specification APT.44/59—ANDHRA PRADESH ELECTRICITY DEPARTMENT and 13 other Taxes and Duties, &c."

Earnest money of ½ per cent. of total amount of Tenders shall be furnished along with the Tender.

Remittances towards cost of specification are not refunded under any circumstances.

Money Order, Postal Orders, and Cheques will not be accepted towards cost of specification.

Specimen copy of the Tender Schedule can be seen at India Store Department, Engineering Branch, Bromyard Avenue, Acton, W.3, under the following reference: S.4022/59/NSC/ENG.2. E8906

COQUET WATER BOARD

FLOW METERING EQUIPMENT

CONTRACT NO. 16

TENDERS are invited for the SUPPLY, DELIVERY and INSTALLATION at the several sites of all or any of the following FLOW METERING EQUIPMENT:

(i) One Recorder and Transmitter for use in connection with a standing wave flume.
(ii) One Rectangular Compound Weir with Recorder and Transmitter.
(iii) One Rectangular Weir with Recorder and Transmitter.
(iv) Eight Differential Pressure Measuring Devices for incorporation in pipelines of Sizes 36in., 30in., 24in. and 18in. diameters, together with Recorders and Transmitters.
(v) Two Mechanical Meters.
(vi) One Instrument Panel.
(vii) Ancillary equipment for the above.

Forms of Tender specifications and drawings, may be obtained from Mr. S. G. Barrett, M.I.C.E., Engineer and Manager of The Coquet Water Board, P.O. Box 104, Pilgrim Street, Newcastle upon Tyne, 1. Tenders are to be returned in envelope provided, to the undersigned, not later than 10 a.m. on 14th March 1960.

The Board do not bind themselves to accept the lowest or any Tender and reserve the right to accept the whole or part of any Tender received.

F. G. EGNER,
Clerk and Solicitor to the Board.

14, Northumberland Square,
North Shields. E8834

INDIA STORE DEPARTMENT

The office of the Director General, India Store Department, Government Buildings, Bromyard Avenue, Acton, W.3, invites TENDERS for the following:

(a) THREE AUTOMATIC CARTRIDGE LOADING, ASSEMBLING AND FINISHING MACHINES for 0·30in. and 9mm. calibre Ammunition.
(b) GEAR SHAPING MACHINE for Gears up to 500mm. dia. Similar to Maschinenfabrik Lorenz Model S.N.5.
(c) GEAR HOBBING MACHINE for hob ing helical gears at high production rates. Maximum Module 6, maximum pitch diameter 600mm., maximum width milled 320mm.

Specifications, &c., can be obtained from the Co-ordination Branch, India Store Department, Government Building, Bromyard Avenue, Acton, W.3, at a cost of 10 shillings per Tender enquiry, and is not refundable. Tenders are to be returned to the above address by Monday, 21st March, 1960.

Specimen copy of the above enquiries can be seen at Engineering Branch, India Store Department, under the following references:

(a) 2032/59/SSB/ENG.3.
(b) 2036/59/SSB/ENG.3.
(c) 2037/59/SSB/ENG.3.

E8950

EDINBURGH CORPORATION

FILTER SAND WASHING AND DEWATERING PLANT

TENDERS are invited for the SUPPLY of a SAND WASHING AND DEWATERING PLANT capable of handling 20 tons of filter sand per hour. Copies of the Specification may be obtained from the City Water Engineer, 6, Cockburn Street, Edinburgh, 1.

Tenders must be lodged in a sealed envelope endorsed "Filter Sand Washing and De-Watering Plant" with the Town Clerk, not later than 10 a.m. on Monday, 21st March, 1960.

The Corporation shall not be bound to accept the lowest or any tender. E8947

TENDERS

CITY AND COUNTY OF BRISTOL

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MAIN PUMPING STATION ANCILLARY EQUIPMENT

Manufacturers suitably experienced for the SUPPLY of:

(a) Curved bar SEWAGE SCREENS approximately 9ft. by 11ft. together with automatic raking gear and pumps for flushing water;
(b) Hand and automatically operated PENSTOCKS of 60in., 42in. and 36in. square opening and 12in. and 9in. diameters;
(c) COMMINUTORS to deal with a sewage flow of 20,000,000 gallons/day for each unit;
(d) Electrically operated 10-TON OVERHEAD CRANE and hand-operated 5-TON OVERHEAD CRANE;
(e) METERING EQUIPMENT for incoming and outgoing sewage flows, sewer and sump level indicators, transmission and recording equipment;

are invited to apply for inclusion in a selected list of firms who will be invited to Tender for the Supply and Erection of the above equipment.

Applications, together with supporting evidence of similar experience, to City Engineer and Planning Officer, Cabot House, Deanery Road, Bristol, 1, by 7th March. E8946

EDUCATIONAL

COVENTRY TECHNICAL COLLEGE

COURSE ON "MODERN MATERIALS"

A Short Course for Chemists, Metallurgists and Engineers on the "PROPERTIES AND INDUSTRIAL APPLICATIONS OF MODERN MATERIALS," will be held on Thursday and Friday, March 31st and April 1st, 1960.

Course Fee: One guinea.

Particulars and application form from Head of Chemistry Department. E8897

A.M.I.MECH.E., B.Sc., City and Guilds, etc. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent successes. 148-page prospectus free, on request.—B.I.E.T. (Dept. 22), 29 Wright's Lane, London, W.8. E114

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INDUSTRIAL ADMINISTRATION (POST GRADUATE)

SECRETARIAL AND BUSINESS TRAINING

Applications for admission for the Academic Year 1960/61 should be made as early as possible, and addressed to Woolwich Polytechnic, London, S.E.18. E8903

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

A FIRM OF LONDON CONSULTING ENGINEERS, specialising in irrigation, invite applications for vacancies of ENGINEERS, age 30 to 35. Irrigation experience desirable but not essential. University Degree and A.M.I.C.E. The posts will carry salaries in the range of £1500 to £1700 per annum. Applications by not later than 26th February, 1960.—BOX No. E2726, "The Engineer." A

APPLICATIONS ARE INVITED from ambitious and resourceful men to fill the position of TECHNICAL ASSISTANT to the Sales Manager of Electric Lamp Machinery Manufacturers near London. A permanent, progressive and interesting job is offered to the right person, who must possess a sound engineering and commercial background in the trade.—Applications, with full particulars of education, experience and salary required, to BOX No. E171, "The Engineer." A

A YOUNG ENGINEER required for Specialised Poducts Dept. Applicants should preferably have the following qualifications : (a) Age up to 24 years ; (b) Post-graduate or equivalent education qualifications ; (c) Knowledge of pneumatic equipment.—Apply in writing, stating experience, also salary required, to : Technical Director, Wellworthy Ltd., Lymington, Hants. E8955 A

CHIEF DESIGNER.—At Duramin we design and build bodywork for a wide range of specialised commercial road vehicles and our product is nationally known for quality. We require a man of extensive engineering experience, both practical and theoretical, to take over control of the drawing-office, with responsibility, after training, for bodywork design, answering to the technical directors and collaborating with sales and project engineers. This is a senior post, offering great interest and variety in an enthusiastic, happy and growing company, where conditions are excellent and where initiative, ability and hard work are recognised.—Write in confidence to Production Director, Duramin Engineering Co., Ltd., Stonefield Way, Ruislip, Middlesex. E2719 A

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A new 400-page book, published to assist Designers and Manufacturers using castings in their own work. This handbook is a guide to the facilities, capabilities and capacities of individual foundries, enabling users to contact a suitable foundry for specific types of work.

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SITUATIONS VACANT

ASSISTANT DESIGN ENGINEER (ELECTRICAL)

required by the United Kingdom Atomic Energy Authority, Production Group, Springfields Works, Salwick, Preston, Lancashire, to be responsible to the Electrical Design Engineer for the layout and design of electrical power and lighting installations for process and ancillary buildings, and design work in connection with the provision and reinforcement of electrical power supplies to the Works. Duties will include preparation of power and lighting designs as a leader of a small team of draughtsmen, preparation of specifications relating to purchase of electrical plant and equipment and technical advice to construction staff engaged on building projects.

A recognised engineering apprenticeship and a Higher National Certificate, or equivalent, in Electrical Engineering, are essential. Good experience in the electrical design field in connection with chemical and metallurgical processes is also required. Familiarity with flameproof equipment, process heating and automatic control systems would be an advantage.

Salary between £930 and £1340, according to qualifications and experience.

Staff Housing Scheme. Contributory Superannuation.

Send postcard for application form, quoting reference SF.28/J1, to Works Secretary at above address.

Closing date : 7th March, 1960.

E8888 A

ASSISTANT DIVISIONAL MANAGER GAS CLEANING

Applications are invited for the above post from suitably qualified men aged 30 to 40 years of age and possessing a University Degree or equivalent in pure or applied science. The successful candidate will have direct responsibility for product development, technical sales and customer liaison and will assume control of the entire division in the absence of the Division Manager.

The Company is an old-established one of medium size situated in the North of England. Its Gas Cleaning Division is rapidly expanding to deal with the demand for its products engendered by the Clean Air Act. It thus presents good opportunities for advancement for the right man.

Candidates should have at least 3 years' experience of Technical Management within the Engineering Industry and some experience of Technical Selling to basic industries would be an advantage.

Starting salary will depend on qualifications and experience but will be not less than £1400 per annum.

Applications, giving full details of age, experience, positions held and the salaries attached, should be sent in confidence to URWICK, ORR & PARTNERS, LTD., who have been asked to advise on this appointment, at URWICK HOUSE, 14, Hobart Place, London, S.W.1, quoting reference ADM/1367.

E8928 A

CHARTERED CIVIL ENGINEER required as Manager of expanding Department in a Contracting Company with international interests. Previous experience in office administration and estimating for and supervision of civil engineering contracts essential. This is an opportunity for a well-trained man, preferably a University Graduate, to build up a worth-while permanent career in an established company based in the provinces, with possibilities of a Directorship in due course. A substantial salary, bonus on results, expenses, car allowance and a pension scheme will be offered, along with a company house at moderate rental and removal expenses. Candidates for this post are invited to apply in own handwriting (in confidence) for further particulars ; also submitting a précis of their education, experience, availability, marital status and basic salary requirement, pending possible further enquiry from and interview with the advertisers.—BOX No. E8878, "The Engineer." A

DRAUGHTSMAN

Applications are invited for the above post, which is located in Birmingham.

The work is interesting and varied and is mainly in connection with the design of industrial heating equipment. A knowledge of combustion technique and the use of refractories would, therefore, be an advantage.

Candidates should possess the Ordinary National Certificate in Mechanical Engineering as a minimum qualification.

The salary for the appointment, which is pensionable and subject to medical examination, will be within the range of £733–£853 per annum.

Applications, stating age, qualifications and experience, together with the names of two referees, should be addressed to the Industrial Relations Officer, West Midlands Gas Board, 6, Augustus Road, Edgbaston, Birmingham, 15. E180 A

ENGINEER required with experience in the installation of light mechanical packing machinery, by International Manufacturers of surgical dressings. Age 28–40. Engineering degree essential, together with knowledge of European languages, preferably French. Successful applicant must be prepared to travel abroad. Commencing salary £1500 per annum. Apply, giving full information.—BOX No. E8917, "The Engineer." A

DESIGNER/DRAUGHTSMEN required, for hydraulic and pneumatic valves. H.N.C. standard. Isleworth area. Applications, with full details and salary required.—BOX No. E8844, "The Engineer." A

ENGINEER required to assist Chief Mechanical Engineer. Age 25–35, preferably with experience in iron or steel works. A recognised qualification is desirable. The post is superannuated.—Apply in writing, giving full details and qualifications, to Labour and Welfare Officer Staveley Iron and Chemical Company Limited, Near Chesterfield. E8875 A

ENGINEER (MECHANICAL).—Applications are invited from Engineers not over 35 years, who possess 1st Class M.O.T. Certificates (Steam). Willing to reside in or near London for duties in that area and to undertake three-monthly tours of inspections of boilers, pressure vessels, &c. in West Africa. Salary in accordance with age, previous experience, if any, plus expenses and allowances. Non-contributory pension scheme. Apply in own handwriting.—BOX No. E8820 "The Engineer." A

ENGINEERING ASSISTANT experienced in the design of reinforced concrete bridges and other structures, capable of supervising drawing-office staff. Salary range £943/£985 per annum. Superannuation fund. Reduced rates of travel and other concessions. 5-day week.—Applications, giving qualifications and experience, to : Chief Civil Engineer, Western Region of British Railways, Paddington Station, London, W.2. E8900 A

ENGINEERING EXECUTIVE with extensive experience, home and export sales, preferably with heavy mechanical and hydraulic equipment, required to assist in general administration of medium-sized company, Woolwich, London district ; preferably within age group 35–40. Full particulars of qualifications and experience.—BOX No. E8962, "The Engineer." A

ENGINEERING, PHYSICS AND SCIENCE GRADUATES or equivalents required for new appointments involving research, design and development work on : (1) Dynamic behaviour of machine tools and problems associated with automatic control ; (2) Press working processes, cold extrusion and other new techniques for the forming of metals ; (3) Machining processes ; initially work will be concerned with the appraisal of new machining developments or studies of machining costs on a comprehensive scale ; (4) Mechanical engineering equipment, including special machine tools, presses, mechanisms, test rigs, &c. Successful candidates will be expected to take complete responsibility for projects from conception to completion. Capacity for creative thinking and initiative are important. The conditions of employment are attractive and there are excellent prospects for advancement. Superannuation scheme. Removal expenses paid.—Send full details in confidence to the Secretary (R.650), Production Engineering Research Association, Melton Mowbray, Leics. E8944 A

EXPERIMENTALIST

required by the United Kingdom Atomic Energy Authority at Dounreay Experimental Reactor Establishment, Thurso, Caithness, Scotland, to assist with development work on experimental rigs and associated components to be irradiated in the materials testing reactor. The work involves many novel features and offers a wide scope in the development of new and improved techniques.

The basic qualification required is G.C.E., or equivalent, in at least five subjects, two of which must be at advanced level in science or mathematics. A pass Degree or H.N.C. in an appropriate subject is desirable. Experience on electro-mechanical work or laboratory techniques would be an advantage.

Salary : £420 (at age 18) to £905.

Contributory Superannuation. Staff housing scheme.

Hostel accommodation available.

Send postcard for application form, quoting reference 176/J1, to Personnel Manager at above address.

Closing date : 29th February, 1960.

E8886 A

MECHANICAL AND ELECTRICAL ENGINEER, aged 30/38, required to act as Assistant to the Chief Engineer of a large group of stadia. Knowledge of building construction an advantage. The position is pensionable and the salary will be commensurate with experience. Please write, giving details of experience and academic qualifications.—BOX No. E2725, "The Engineer." A

ONE SENIOR ELECTRICAL DRAUGHTSMAN with experience in the control of Crane and Hoisting and Machinery. Contributory Pension Scheme, Canteen.—Apply in writing, stating age, salary required, previous training and experience to Woodfield Rochester Ltd., Frindsbury Works, Rochester, Kent. E8926 A

PROGRESSIVE COMPANY IN MIDLANDS requires young DESIGNER DRAUGHTSMAN for Specialised Rotating Electrical Machinery. The position offers great opportunity to keen, energetic man, with ideas, wishing to gain from his skill and efforts. Write fully.—BOX No. E8912, "The Engineer." A

SALES ENGINEER for manufacturing company of international repute connected with the oil industry. There will be a training period. Applications are invited from young Engineers of good presence and address, either University training or with H.N.C. Only those with the required qualifications should apply. Excellent prospects. Write fully.—BOX No. E8894, "The Engineer." A

SALES TECHNICIAN required by English Agents of world-famous Optical and Scientific Instrument Manufacturers. Short training abroad. Must be prepared to travel in U.K. Salary and commission.—BOX No. E2720, "The Engineer." A

SENIOR ASSISTANT CIVIL ENGINEER—age 26–36 approximately—required in Consulting Engineer's office in Nigeria. Successful applicant required to act as Deputy to Resident Partner. Mainly roadworks and bridgeworks. Fifteen months' tour with three months' paid U.K. leave. Salary £1800 approximately—furnished accommodation provided.—Apply, R. TRAVERS MORGAN & PARTNERS, 161/6, Fleet Street, London, E.C.4. E8961 A

Classified Advts. continued on page 108

SITUATIONS VACANT

SAO PAULO LIGHT S.A.—SERVICOS DE ELETRICIDADE, a company in Brazil and a subsidiary of the Canadian Corporation Brazilian Traction, Light and Power Company, Limited, invite applications from suitably qualified men for the position of SHIFT CHARGE ENGINEER in the Piratininga Power Station. The power station, put into service about five years' ago, is situated near Sao Paulo (population over 3 millions ; temperate climate ; 2200ft. above sea level). The plant comprised initially 2×80MW., 1800 r.p.m., steam turbo-alternator units, each supplied at 850 p.s.i., 900 deg. F., by one 850,000 lb/hour oil-fired boiler, and is now being expanded by the addition of two 125,000 kW. reheat units, 1800 p.s.i., 1000 deg. F. Applicants should have a sound technical knowledge and wide experience of the operation of modern turbines and boilers, preferably with oil or pulverised-fuel firing ; should also have an aptitude for supervision and the maintenance of harmonious labour relations. Good salary, three years' agreement with first-class passage both ways, with family ; four months' paid leave after three years' service.—Written application in the first instance should be made to Mr. Osborne Mitchell, General Manager, CANADIAN-BRAZILIAN SERVICES LTD., 9/12, Cheapside, London, E.C.2. E8941 A

SENIOR DESIGN/SECTION LEADER DRAUGHTSMAN.—A large Steelworks in the Midlands wishes to appoint a Senior Design/Section Leader Draughtsman. Applicants should possess steelworks development experience associated with furnaces, rolling mills and general building work. The post is a progressive one and a pension and free life assurance scheme are in operation. Applications, giving qualifications, details of experience and salary required.—BOX No. E8895, " The Engineer." A

STEELWORK DESIGNER required by Consulting Engineers, Westminster. Age 30–40. Experience in all kinds of light and heavy construction work, determinate and indeterminate (rigid) frames, for industrial installations, &c. Salary to be determined according to experience.—BOX No. E8893, " The Engineer." A

STEEL WORKS PROJECT ENGINEER

An opening offering good prospects is available for a man of proved ability qualified in the layout and operation of Steel Works Plant and the co-ordination of requirements for Heavy Shears, Handling Equipment and Ancillary Gear, &c.

Applicants should be able to guide general designs to meet specifications and supervise the manufacture and building of complete equipments.

In the first instance, please give full details of age, training and experience.

Write, BOX No. E8958, " The Engineer."

A

TECHNICAL SALES ENGINEER, preferably with experience of tube and rod drawbenches, similar heavy metal-working equipment and preferably resident Midlands, to represent London firm manufacturing heavy American equipment under licence. Existing connection with users of this type of equipment an advantage. Write, stating qualifications, experience, age, &c.—BOX No. E8861, " The Engineer." A

THE REED PAPER GROUP

has a vacancy for an

INSTRUMENT PROJECT ENGINEER

for interesting and varied work in connection with the application of process control instrumentation in the paper industry. The work involves the design, specification, calculations and selection of instruments for project work within the Group.

Applicants, aged 25–35, should have minimum qualification of H.N.C. in Electrical or Mechanical Engineering, with several years' experience in the field of control engineering. Previous experience in the paper industry is desirable, though not essential.

The appointment is in Kent. The Group operates a non-contributory pension scheme and assistance with house purchase will be available if required.

Applications, stating age, experience, qualifications and quoting reference IPE/GE/E/66, should be addressed to :

The Group Personnel Officer,
Albert E. Reed & Co., Ltd.,
LARKFIELD, NR. MAIDSTONE, KENT.

E8907 A

WANTED, FIRST-CLASS SENIOR DESIGN DRAUGHTSMAN for firm of General Engineers in Bristol. Good knowledge of general engineering, with particular reference to pressure vessels and stainless steel fabrication. This will be a well-paid position for the top-class man.—BOX No. E164, " The Engineer." A

WORKS MANAGER with knowledge of tube manufacture. Must have wide experience in practical and executive appointments, held similar positions and be a first-class administrator. Substantial salary will be paid to man with necessary qualifications, and future prospects are excellent.—Apply in confidence to the Managing Director, The Phoenix Steel Tube Co., Ltd., Phoenix Street, West Bromwich. E8644 A

LOTUS LTD.
STAFFORD

WORKS ENGINEER

There is a vacancy at the Stafford shoe factory of Lotus, Ltd., for a Works Engineer to take charge of all aspects of factory maintenance. Experience of installing and maintaining production machinery is essential, together with a practical knowledge of electrical and building trades work and all the normal works services. This is a staff position, carrying a salary commensurate with the responsibilities involved, and offers good prospects for the future.—Please apply by letter giving complete details of education, qualifications and experience together with an indication of present earnings, to the Personnel Manager, Lotus Ltd., Sandon Road, Stafford.

E8954 A

PROJECT ENGINEER

required by nationally-known engineering company in the Manchester area, specialising in Rubber, Plastic and Hydraulic Machinery.

Applicants should have initiative and a high sense of responsibility, a University Degree or equivalent. He will be required to meet customers and discuss their problems with a view to getting out the necessary designs and drawing up of specifications, experience in Rubber or Plastic industry or plant would be an advantage.

This post has a non-contributory pension and life assurance scheme.

The staff have been advised of this vacancy.

All applications will be treated in the strictest confidence.

Write in the first instance to :

Personnel Manager,
FRANCIS SHAW & CO. LIMITED,
Corbett Street, Ashton New Road,
Manchester, 11.

E8827 A

TECHNICAL ASSISTANT

BRITISH OXYGEN GASES LIMITED

wish to recruit a Technical Assistant to work in one of their Development Groups. In general he would be required to assist qualified engineering personnel engaged on various projects. The specific responsibilities would include :—

(a) The building of test rigs and assisting in the construction of prototype equipment.
(b) Carrying out tests and experiments in accordance with detailed instructions and fully recording the procedures and results.

Candidates should be within the age group of 18/25 years and should have served a recognised Engineering Apprenticeship. An Ordinary National Certificate in Mechanical or Electrical Engineering would be preferred, together with a good general standard of education.

This is an interesting opportunity for the right person, and there are bright prospects for the future.

Write giving particulars of qualifications and experience to:—

PERSONNEL MANAGER,
BRITISH OXYGEN GASES LIMITED,
SPENCER HOUSE, ST. JAMES'S PLACE,
LONDON, S.W.1.

E8936 A

J. STONE & CO. (DEPTFORD) LTD.
ARKLOW ROAD, S.E.14.
require immediately:

ENGINEERS
For work involving steam technology. Engineering Degree standard preferred but will consider applicants with H.N.C. if supported by relevant practical experience.

SENIOR DRAUGHTSMAN (ELECTRICAL)
Conversant with schematic wiring diagrams and electrical installations on railway rolling stock. Should have minimum of O.N.C.

DRAUGHTSMEN (SENIOR & JUNIOR)
For research and development work. Should have served an apprenticeship and have minimum of O.N.C.

LABORATORY TECHNICIANS
For research and development work. H.N.C. standard required, and should have electrical/mechanical experience.

Salary according to age and experience. Interesting work with good prospects, Pension scheme, staff canteen, sports club.

Applications giving age, education and experience to: **Personnel Manager.**

E8937 A

FRANCIS SHAW & CO. LIMITED
Rubber, Plastics and Hydraulic Machinery Engineers,
MANCHESTER

The Company invites applications for the following appointments :—

PROJECT ENGINEER, to carry out original design work and the preparation of necessary specifications and be capable of dealing with customers' technical problems on specialised designs.
This is a senior post requiring an enterprising man with graduate or equivalent qualification, who will be prepared to travel extensively abroad.

SALES ENGINEER with sound engineering ability, preferably in the rubber and/or plastics industries, aged 28 to 35 years.
The possession of H.N.C. Engineering will be an added advantage. The successful applicant will get a thorough training in all aspects of this work.

ESTIMATOR with Drawing Office experience in medium/heavy engineering, preferably trained in Commercial Estimating, where a high standard of technical correspondence was required.
The possession of H.N.C. in Mechanical Engineering would be an advantage.

HYDRAULIC DRAUGHTSMAN for the design and detailing of hydraulic presses and ancillary equipment. Applicants should have experience in press and press circuitry design and have the minimum qualification in Mechanical Engineering of an Ordinary National Certificate.

MECHANICAL DRAUGHTSMEN for the design and detailing of a wide variety of medium/heavy products for the rubber and plastics industries.
Applicants must have the minimum qualification in Mechanical Engineering of an Ordinary National Certificate.

JIG & TOOL DRAUGHTSMAN for the design and detailing of Laboratory Equipment and special purpose machinery.
Applicants should have had experience in this type of work, including the design of Die-heads and Moulds, preferably as applied to the rubber and plastics industries. Applicants must have the minimum qualification in Mechanical Engineering of an Ordinary National Certificate.

ELECTRICAL DRAUGHTSMAN for the design and detailing of circuit diagrams and conduit layouts.
Applicants should have had experience in motor control gear and diagram work and should be in possession of the minimum qualification in Electrical Engineering of an Ordinary National Certificate.

The Company operates a non-contributory Pension Fund and Life Insurance Scheme.

Applications, which will be treated in confidence, should give fullest information and salary required and be addressed in writing to the Personnel Manager, Corbett Street, Manchester, 11. E8914 A

BRITISH *Enka* LIMITED

PRODUCERS OF MAN-MADE FIBRES

ELECTRICAL ENGINEER

Required as Senior Assistant to the Chief Electrical Engineer in a large, modern plant. Experience of installation, maintenance and operational work of E.H.T. and M.V. systems and ability to organise and handle labour essential. Minimum qualifications A.M.I.E.E., or equivalent. The successful applicant must be able to take over in the absence of the Chief and a good salary will accordingly be paid.

The Company is extending its activities by the production of Cellulose Films and the prospects of advancement are good.

Pension Scheme with facilities for transfer, assistance with housing.

Applications, in confidence, should state age, qualifications, experience, in sequence, and be addressed to Personnel Manager.

BRITISH ENKA LIMITED,
AINTREE, LIVERPOOL. E8925 A

The world's leading inventors and manufacturers of special purpose precision machinery for the Tobacco Industry have opening in their London Drawing Office for:—

MECHANICAL DESIGNER

Applicant should be qualified Engineer, age 25—35, of sound practical experience and with original and inventive mind, receiving recognition in his present post on that account.

This opportunity is permanent and progressive and holds promise of absorbing work on most attractive terms. Applications, stating age, qualifications and experience, should be personally addressed in confidence to G. B. Salmon, **MOLINS MACHINE COMPANY LTD., Evelyn Street, London, S.E.8.**

E8892 A

SITUATIONS VACANT

METALLURGICAL CHEMIST

is required by

W. H. ALLEN SONS & CO., LTD.,

to take charge of the Chemical Section of the Metallurgical Laboratory at their Queens Engineering Works, Bedford. Applicant should possess at least H.N.C. and have experience in ferrous and non-ferrous analysis. A knowledge of corrosion and Works processes, i.e. electro-plating, an advantage. The work, which is varied and interesting, includes the training of junior staff. (Ref. 1601/D1/2.)

METALLOGRAPHER

is also required,

to take charge of a Section of the above-mentioned Laboratory dealing with micrography and photography, including the investigation of unusual service failures. A knowledge of works processes, such as welding, metal spraying, hard surfacing, etc., would be an advantage. Ability to write clear and concise reports essential. (Ref. 1601/D2/2.)

Permanent appointments with a good Staff Pension and Life Assurance Scheme. Apply, stating age and experience (quoting reference No.), to the Personnel Manager, W. H. Allen Sons & Co., Ltd., Bedford.

E8901 A

SITUATIONS VACANT

WORKS ENGINEER

required by Permanite Ltd., roofing felt manufacturers, for their Hertford Works.

Duties—maintenance and development of existing, and installation of new, plant and premises.

Age 25-30. H.N.C. essential. Pension scheme. Use of Company's car.

Replies, giving full details of qualifications and experience, to Chief Engineer, Permanite Ltd., 455, Old Ford Road, E.3.

E8828 A

SITUATIONS VACANT

FRANCIS SHAW AND COMPANY LIMITED

require

A PRODUCTION MANAGER

30 to 40 years of age, to take charge of overall planning and progressing production for works engaged in the manufacturing of medium/heavy machinery for the rubber and plastics trades and employing approximately 750 persons. Candidates must have attained a position of responsibility in a substantial manufacturing organisation and have expert knowledge of production control, including punched card systems, and will be responsible for compiling and maintaining delivery schedules. Mechanical Engineering apprenticeship with a Professional qualification is preferable. The suitable applicant will be responsible to the Works Director.

AN ASSISTANT TO THE WORKS DIRECTOR

30 to 40 years of age, who will assist in controlling the practical activities of a works employing approximately 750 persons and manufacturing medium/heavy machinery for the rubber and plastics trades. The successful candidate must have a thorough knowledge of the latest tooling methods and must have served in a position of responsibility in a substantial manufacturing organisation. A Mechanical Engineering apprenticeship is essential and a Professional qualification preferable.

A generous non-contributory pension scheme is in operation for each of these appointments.

Applications, which will be treated in confidence, should give fullest information and salary required, and be addressed to the Secretary, Corbett Street, Manchester, 11.

E8826 A

SITUATIONS VACANT

PA

PERSONNEL ADMINISTRATION LIMITED

MANAGEMENT CONSULTANTS

Our Appointments Division has been asked to advise on the following posts :—

FIRE PROTECTION DESIGNERS

AUSTRALIA

A leading Australian group of companies which is active and expanding in the field of fire protection requires competent and experienced Fire Protection Designers for work on fire protection sprinkler systems. Salary up to £1,800 (Aust.) depending on qualifications. Preferred age 24–40. Modern houses will be provided in pleasant surroundings close to the Works, and the persons appointed will be able to purchase their houses on easy terms if they wish. The company will pay the fares to Australia of the men selected and their families; also up to £100 towards cost of removal. Vacancies exist in Sydney and Melbourne. (Ref. 3365/TE.)

The identity of candidates will not be revealed to our clients without their prior permission.

For the convenience of clients and candidates we have Regional Offices in **Glasgow, Manchester** *and* **Birmingham** *but, in the first instance, applicants should forward brief details, quoting the reference number, to :—*

PERSONNEL ADMINISTRATION LIMITED

APPOINTMENTS DIVISION

2 ALBERT GATE, LONDON, S.W.1.

E8908 A

SITUATIONS VACANT

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

has a number of vacancies for

MECHANICAL AND ELECTRICAL ENGINEERS

To cover a variety of duties in the ENGINEERING SERVICES and WORKSHOPS SECTION of a Research Establishment. Candidates should be Corporate or Graduate Members of a Senior Professional Institution, with good background and experience of engineering work and services. They should be versatile men with adaptable minds who are prepared to undertake diverse duties rather than specialise in one field.

SALARY : From £860–£1825, according to age, qualifications and experience.

The Establishment is in pleasant rural surroundings, with good recreational facilities, not far from London. Conditions of work are excellent and include superannuation scheme, 5-day week, and liberal leave allowance. A house, or substantial assistance with house purchase, will become available for married officers living beyond daily travelling distance.

POSTCARDS for application forms to the Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks. Please quote ref. 2541/25.

E8896 A

SENIOR DRAUGHTSMEN

experienced in bulk mechanical handling or foundry work. Superannuation Scheme. Five-day week. Apply to MARCO CONVEYOR & ENGINEERING COMPANY Ltd., Lynn Road, Leytonstone, London, E.11. LEY 2254.

E8805 A

W. H. ALLEN SONS & CO., LTD.

invite applications for the following vacancies at their Atlas Works, Pershore, Worcestershire.

SENIOR and JUNIOR DRAUGHTSMEN for expanding Gear Drawing Office. Candidates with general mechanical engineering experience, not necessarily connected with gearing, would be considered.

CONTRACTS ENGINEERS for expanding Gear Sales and Service Section. The work involves estimating and the preparation of tenders, including after-sales service. Candidates should be at least 24 years of age, and have received a recognised engineering training, with subsequent experience in drawing or estimating office.

The above appointments cover interesting work on high-power gearing, individually designed for special industrial and marine applications. Permanent pensionable positions. Canteen facilities. Travelling allowance according to distance from Pershore. —Apply, in confidence, to Personnel Manager (Ref. 829/274), Atlas Works, Pershore, Worcestershire. E8835 A

THE ENGLISH ELECTRIC COMPANY LIMITED,

MECHANICAL ENGINEERING LABORATORIES

RESEARCH AND DEVELOPMENT IN INDUSTRY

At Whetstone in Leicestershire the English Electric Company has set up in pleasant rural surroundings a central research and development department to maintain and enhance the high degree of mechanical excellence essential to its wide range of products. In these laboratories the emphasis is on quality, and the work ranges over the whole field of mechanical disciplines, including structures, strength of materials, vibrations, friction and wear, lubrication, fluid mechanics, controls, heat transfer, thermodynamics, combustion and mathematics.

If you have ability and initiative and are interested in doing fundamental research to provide new techniques or new data, you will find opportunities for satisfying and rewarding employment in these laboratories. The work should appeal especially to people with distinguished degrees in engineering, physics, chemistry or mathematics, and young men in particular should find a great stimulus and opportunity in the close association which the laboratory maintains with Product Departments.

If this prospect appeals to you and you have the qualifications needed, we should be glad to have an

INFORMAL DISCUSSION

with you, at MARCONI HOUSE, 336/7, STRAND, W.C.2, on Friday, 26th February, 1960, from 6.00 p.m. to 8.00 p.m., or Saturday, 27th February, 1960, from 9.30 a.m. to 11.30 a.m. There is no need to make an appointment.

Alternatively you may be interested in one of the specific topics mentioned in the following examples, in which case, we shall be pleased to receive written enquiries at Dept. C.P.S., Marconi House, Strand, London, W.C.2: please quote ref. E 1950 D.

1. **Fluid Machines**—the provision and improvement of cascade theories for the design of fluid machines.
2. **Hydrodynamic Lubrication**—studies of oil whirl and cavitation.
3. **Combustion**—a study of the fundamental processes of combustion, in the first instance with reference to diesel engines. It is hoped, for example, to study heat release and methods for its control, but to do this it will probably be necessary first to provide more refined instruments and apparatus.
4. **Structures**—the application of refined structural analysis to such mechanical structures as engine and locomotive frames. In this work an engineer would have the support of the Mathematics Group of the laboratory, which is equipped with a digital computer. Theoretical studies will be supported by experiments, both static and dynamic.
5. **Vibrations**—research into and development of methods of vibration analysis—currently particular significance attaches to coupling effects and fluid excitations.

E8929 A

Classified Advts. continued on page 110

SITUATIONS VACANT

MSL *have been retained to advise on the appointment of an*

ASSISTANT DEVELOPMENT MANAGER

for an engineering company, employing about 1,000, which has pioneered the development of domestic and commercial heating and catering equipment for over a century.

The Assistant Development Engineer will have specific responsibility for the design and development of gas-fired heavy duty equipment, with wider interests in oil, steam, electrical and solid fuel appliances. He will have contacts at all levels within the company, and with users and suppliers.

Candidates must have broad general engineering experience, including design and production, and a knowledge of heating and catering installations. A B.Sc., degree or professional membership would be an asset.

Preferred age 25 to 35 years. Initial salary in the range £1,250 to £1,500 with non-contributory pension and life insurance.

Please send brief details in confidence, quoting reference G.2211, to J. G. Smith. In no circumstances will a candidate's identity be disclosed to our client unless he gives permission after a confidential interview at which he will be given full details of the appointment.

MANAGEMENT SELECTION LIMITED
212, West Regent Street, Glasgow, C.2

E135 A

SITUATIONS VACANT

MSL *have been retained to advise on the appointment of a*

CHIEF DEVELOPMENT ENGINEER

for a well established firm of medium heavy engineers in the North Midlands operating more than a dozen factories. The company manufactures highly specialised products and is divided into divisions each with a General Manager.

The Chief Development Engineer will be responsible to the General Managers for the development of new products and improvements to existing products, for new methods of manufacture and improvements to existing methods and for the development of new uses for the company's products. Basic research is not involved.

Candidates must have an honours degree in engineering and have experience of the cold working of metals in the factory as distinct from the laboratory; such experience in the field of high tensile steel would be an advantage. Age: 32 to 45. Salary £2,500. Car provided. Non-contributory pension and exceptional life insurance cover.

Please send brief details in confidence, quoting reference G.1939, to H. A. P. Disney. In no circumstances will a candidate's identity be disclosed to our client unless he gives permission after a confidential interview at which he will be given full details of the appointment.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E134 A

SITUATIONS VACANT

MECHANICAL ENGINEER

A well-known industrial Organisation wishes to recruit a Mechanical Engineer, not necessarily fully qualified, who could be responsible for the installation and maintenance of small plants of a continuous process nature in customers' premises. He would be a member of a Management team.

Opportunity will occur both in the field and at Head Office on specific projects.

An attractive salary is offered which will not be below £1000.

Write stating full details.—

BOX No. E8934, "The Engineer."

A

SITUATIONS VACANT

HENRY WIGGIN & COMPANY, LIMITED
require
TWO MECHANICAL OR ELECTRICAL ENGINEERS
for their new and expanding Hereford Works.

Initially the successful candidates will be required to assist in the planning and layout of two new major sections of the Company's hot-working operations for high-nickel alloys. They will take part in the supervision and the erection of the equipment and should be capable of assuming, in approximately 2 years' time, Production Management responsibility for it.

Preferred age 27–35. Qualified engineers only need apply. Salary in accordance with experience and qualifications. Excellent Canteen, Welfare and Recreational facilities. Non-contributory Pension and Life Assurance Schemes.

Apply in writing, giving full particulars, to:

Personnel Manager (Ref. P.1), Henry Wiggin & Company, Limited, Wiggin Street, Birmingham, 16.

E8916 A

MECHANICAL ENGINEER

Graduate Mechanical Engineers with mathematical ability are invited to apply for a position in the mechanical section. The work involves solution of specialist problems associated with Piping Design and includes Piping Flexibility and Stress Analysis, Structural Vibration Analysis and Analysis of Pulsating Fluids in pipeline systems. Applicants should have a university degree in Mechanical Engineering and preferably two years' experience in industry. Salary will be commensurate with qualifications, experience and capabilities. Comprehensive personnel benefits include contributory pension scheme, luncheon vouchers, excellent working conditions and social club.

Please write to Mr. R. H. Paterson

KELLOGG INTERNATIONAL CORPORATION
7-10 CHANDOS STREET, LONDON, W.1.

E8930 A

SHELL

THE ROYAL DUTCH/SHELL GROUP

require

CHEMICAL ENGINEERS

IN HOLLAND

for

DESIGN, DEVELOPMENT,

TECHNOLOGICAL AND

OPERATIONAL WORK

Applicants should possess an Honours Degree in Chemical Engineering or the equivalent professional qualification, with at least 5 years' relevant experience.

The upper age limit is 35 years.

Applications with full details to:

SHELL INTERNATIONAL CHEMICAL COMPANY LIMITED,
Personnel Recruitment/H6,
St. Helen's Court, Gt. St. Helen's, London, E.C.3.

E8647 A

ENGINEER

HUNTINGTON HEBERLEIN LTD.

A SUBSIDIARY OF SIMON-CARVES LIMITED

have a vacancy in their small development team based at CHEADLE HEATH, STOCKPORT, for

A DEVELOPMENT ENGINEER

The duties will be largely concerned with development work on materials handling for sinter and ore preparation plant.

Applicants must have a good degree in mechanical or chemical engineering and some previous industrial experience. Preferred age 30 or less. This post is permanent and pensionable. Salary depends on experience and qualifications. Five-day week. Three weeks' annual holiday.

Send brief relevant details to Staff & Training Division,
SIMON-CARVES LIMITED, Cheadle Heath, Stockport, Cheshire,
quoting ref. ZZ.76.

E8909 A

SENIOR DEVELOPMENT ENGINEER

(Heat Exchange)

for a long-established and important engineering company in the Manchester area. The commencing salary will be £1500 p.a., with considerable prospects of improvement, together with pension scheme.

The problems of heat exchange are involved in a very large part of the Company's products. The Senior Development Engineer will, amongst other things, guide the Drawing Offices on structural design of all orders received and liaise with Works Management on the engineering aspects of manufacture of all heat exchangers. He will also be in close touch with the market and draw up specifications for new ranges of heat exchangers and/or modifications to existing ranges, having in mind competition and cost of manufacture.

The Company's equipment is up to date and working conditions are highly congenial from all points of view.

Qualifications should include a sound theoretical knowledge, preferably A.M.I.Mech.E.; protracted shop floor experience; appreciation of inter-relation of design and cost of manufacture; a strong commercial sense of the product. Age 30–40.

Please write in first instance, quoting Reference No. 615, to :—

AA LTD

ASHLEY ASSOCIATES LTD.
PETER HOUSE, MANCHESTER 1.
RETAINED TO ADVISE ON THIS APPOINTMENT
The strictest confidence will be observed and no details of candidates will be passed to clients without candidates' permission.

E8856 A

SITUATIONS VACANT

BRITISH TRANSPORT DOCKS

invite applications for

RESIDENT ENGINEER

at King George Dock, Hull

He will be responsible to the Chief Docks Engineer for the supervision of a series of civil engineering contracts (aggregate value some £3M.) extending over a period of about three years, including the construction of reinforced concrete quays, steel-framed transit sheds, concrete and brick buildings, extensive roadworks and permanent way installations.

A candidate for this position must be a Chartered Civil Engineer with considerable experience in dock and harbour engineering construction, including piling, and be available, if selected, to take up the appointment at an early date.

Salary according to qualifications and experience, in the region of £1500 per annum.

Applications, giving particulars of age, qualifications, recent experience and referees, to : Staff and Establishment Officer, British Transport Docks (T.E.), 163, Euston Road, London, N.W.1, to arrive not later than Friday, 26th February, 1960. E8919 A

SITUATIONS VACANT

CITY OF BIRMINGHAM WATER DEPARTMENT

ASSISTANT ENGINEERS

Applications invited from Chartered Civil Engineers for above appointments. Salary within : (*a*) Grade A.P.T. IV., £1065–£1220 per annum (considerable water engineering experience essential), and (*b*) Special Grade for Engineering Ass'tants, £785–£1070 per annum (water engineering experience desirable). The Engineer appointed to (*a*) would be engaged upon development of new source of supply, and (*b*) on new water supply works in or near Birmingham. Appointments permanent and pensionable—medical examination. Canvassing disqualifies.

Application forms from General Manager, Water Department, Council House, Birmingham, 3, returnable by 3rd March, 1960. E8942

SITUATIONS VACANT

GENERAL WORKS MANAGER

A General Works Manager is required for a company of ironfounders and engineers specialising in alloy and high duty castings. The Company, located on the borders of Yorkshire and Lancashire, employs 150 men and is part of a well-known engineering group employing over 6000.

The General Works Manager's duties will be administrative as well as technical : he will be responsible to the Managing Director for the co-ordination and efficiency of all production departments. Candidates must have sound experience in engineering jobbing work and be fully conversant with works and piece-work costing ; foundry experience would be an advantage.

The appointment is part of a policy of expansion and it is intended that it should lead to promotion to the Board. Starting salary will be about £2250.

Applications, which will be treated in confidence, should be marked "Personal YA.3," and sent to A. G. P. Elliott, Chief Personnel Officer, SIMON-CARVES LTD., Cheadle Heath, Stockport, Cheshire. E8931 A

SITUATIONS VACANT

A. MONK & COMPANY, LIMITED, WARRINGTON, LANCS.

REQUIRE SITE ENGINEERS for major projects in and around the North Western, North Eastern and South West Midland areas. Permanent and progressive posts. Superannuation Scheme in operation. Applications in confidence stating age, full details of experience and qualifications, etc.—Please reply to Mr. H. Hudson, Personnel Department, A. Monk & Company, Limited, Padgate, Warrington, Lancs.

E8872 A

THE CALTEX ORGANISATION

require

DESIGN ENGINEERS

for service both in London and overseas, to perform design work for oil refineries and associated facilities.

General requirements are :—

(a) Degree in Mechanical or Chemical Engineering.

(b) 2 to 4 years' experience in oil or chemical industry.

Preferred age group 28–32 years. Commencing salary would be dependent upon qualifications and experience. For Foreign Service, additional living allowances are paid and free medical attention, air-conditioned accommodation provided, plus an initial kit allowance and attractive vacation and Benefit Plans.

Apply in writing, quoting "ETS," with full particulars of qualifications and experience, to Caltex Services Limited, Caltex House, Knightsbridge Green, London, S.W.1.

E8959 A

VESSEL ENGINEER

with design and workshop experience covering large columns, pressure vessels, tanks and heat exchangers required by an Oil Refinery and Petrochemical engineering company of international repute.

Applicants must be thoroughly conversant with British and American specifications and codes of practice in these fields and hold A.M.I. Mech.E.

Initial salary in the region of

£1850 p.a.

according to experience and ability.

Write, giving full details of employment to date, and age, etc., in confidence.—BOX No. E8915, "The Engineer."

A

CAM DESIGNER

required, familiar with Tornos Sliding Head automatics. Four-figure salary to an experienced man able to produce the desired results. Acton area. Write BOX No. E8953, "The Engineer."

A

REFINERY AND CHEMICAL PLANT CONSTRUCTION COMPANY REQUIRE A

PROJECT ENGINEER

We are looking for a first-class man who has extensive experience of the planning and overall management of the erection of large-scale heavy industrial plants.

The successful applicant will be based in London but will be required to make frequent visits to sites throughout the country.

Commencing salary in the region of

£2,000 p.a.

according to experience

Write giving full details of experience, etc., in strict confidence, to BOX No. E8932 "The Engineer."

A

Another opportunity in Iron and Steel

BISRA

RESEARCH ENGINEER

to participate in an ambitious project aimed at the development of new types of rolling mills for the metal industries of the late 'sixties.

This is a particularly attractive opening for a Mechanical Engineer in his twenties to exercise his creative abilities to the full, and to gain a vantage position in a field of great scope and reward. The important qualifications for success in this job are a good grounding in modern engineering science and an inventive turn of mind. Lack of experience of metals technology is no handicap.

The post is centred in the Association's laboratory in Sheffield with visits to steelworks and contacts with the design and development departments of leading makers of heavy engineering equipment. Initial salary will be assessed according to age, qualifications and experience in the range £950–£1200 with opportunity for rapid advancement by merit.—Applications, quoting "M.W.17," to Personnel Officer, The British Iron and Steel Research Association, 11, Park Lane, London, W.1. E8957 A

BRITISH OXYGEN GASES LIMITED

ELECTRICAL ENGINEER

An Electrical Engineer between 25 and 30 years of age is required for interesting development work in connection with power units and control gear for inert gas welding. A knowledge of electronics is an advantage, and the candidate should possess a degree or H.N.C. in Electrical Engineering.

TECHNICAL ASSISTANTS

Technical Assistants are also required in the age range 25–30. They should have an electrical background and an H.N.C. in Electrical Engineering would be preferred. Candidates should have a knowledge of electronics or development experience in industry.

There are good future prospects and very good commencing salaries are offered. Please reply stating full particulars to:

THE PERSONNEL MANAGER, SPENCER HOUSE, ST. JAMES'S PLACE, LONDON, S.W.1.

E8935 A

SITUATIONS WANTED

SALES REPRESENTATIVE, negotiator with Civil Engineering and Building World, seeks change of position. Wide experience and contact with Consulting Civil Engineers, Structural Engineers, Architect, Government Departments and Railways, &c., throughout the United Kingdom and Eire. Known to be energetic and a pioneer.—BOX No. E2721, "The Engineer." B

BUSINESS OPPORTUNITIES

REMPLOY SPONSORSHIP SCHEME.—Send for details which show an attractive proposition to manufacturers.—Write to the Managing Director, Remploy, Ltd., 25–28, Buckingham Gate, S.W.1, or telephone VICtoria 6621 (12 lines). E155 O

AN OPPORTUNITY FOR A SMALL ENGINEERING WORKS WISHING TO SECURE ITS FUTURE

Well-known and long-established engineering company in South Midlands is anxious to acquire controlling interest in well-equipped general engineering works employing 200-300 men, mostly skilled, and having a balanced machine shop and fitting shop capacity suitable for building steam turbines. Maximum sizes of machine tools required are based on No. 3 horizontal boring mills, 36in. centre lathes and 48in vertical mills. —Reply BOX No. E8852, "The Engineer."

O

SUB-CONTRACTING

KELLERING AND CAM PROFILING capacity up to 8ft. by 6ft. or 6ft. diameter.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry, Knottingley, Yorkshire (Telephone : Knottingley 2743/4). E116 MW

CAPACITY REQUIRED for the manufacture of Copper/Brass evaporators and condensers for refrigeration and air conditioning units.—Will any firms in the London area who have capacity for this work available please send full particulars to BOX No. E8922, "The Engineer." MW

PATENTS

THE PROPRIETOR of British Patent No. 742,957, entitled "DIAMOND DRESSING TOOL," offers same for Licence or otherwise to ensure practical working in Great Britain.—Enquiries to Singer, Stern and Carlberg, 14, E. Jackson Blvd., Chicago 4, Illinois, U.S.A. E8904 H

MISCELLANEOUS

MOBILE LIFTING SERVICES.—Lump sum or Hire Rate Quoted for any Lifting Work by Lorry-Mounted or Crawler Cranes, any size, any area.—TARSLAG, LTD., Rotherham 3235. E166 I

TECHNICAL TRANSLATIONS in and from French, German or Esperanto ; and from English, Spanish, Italian, Dutch or Portuguese.—J. Höhn, Strittackerstr. 40, Winterthur 6, Switzerland. E8952 I

Classified Advts. continued on page 112

FOR HIRE

LATTICE STEEL ERECTION MASTS (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1. E103 K

600

FORK LIFT TRUCKS FOR HIRE

Modern Machines Only
Diesel & Battery/Electric
Capacities 2000 lb–18,000 lb.
Contact your nearest Depot :

GEORGE COHEN,

SONS & CO. LTD.
WOOD LANE, LONDON, W.12.
(Shepherds Bush 2070)
And at Stanningley (Nr. Leeds) . Kingsbury (Nr. Tamworth) . Manchester . Glasgow Swansea . Newcastle . Belfast . Sheffield Southampton . Bath

E200 K

AGENCIES

AGENT WANTED for progressive company manufacturing open type steel flooring, steel staircases, steel fabrications. London and Home Counties. Must have connections with nationalised industries, consultants, oil refineries and general engineering companies. Write, giving full details.—BOX No. E2724, "The Engineer." D

MACHINERY Etc. WANTED

WANTED.—SECOND-HAND OVERHEAD TRAVELLING CRANE, 40/50-ton capacity, 40ft.–60ft. span, to suit 400 volt, 3-phase, 50 cycle supply. Advertiser is actual user.—BOX No. E2713, "The Engineer." F

FOR SALE

RAILS FOR SALE

100 TONS NEW, SLIGHTLY DEFECTIVE B.H. RAILS, 95 lb. yard, chiefly 60ft.
100 TONS SLIGHTLY DEFECTIVE F.B. RAILS, 109 lb. yard, chiefly 60ft. lengths.
100 TONS NEW, SLIGHTLY DEFECTIVE F.B. RAILS, 91 lb. yard, chiefly 42ft.
100 TONS GOOD SECOND-HAND B.H. RAILS, 80-85 lb. yard, B.S. Section, chiefly 60ft.
100 TONS SECOND-HAND BULL HEAD RAILS, 90-95 lb yard, chiefly 44ft. 6in. lengths.
50 TONS NEW, SLIGHTLY DEFECTIVE F.B. RAILS, 93·34 lb yard, chiefly 41ft.
100 TONS NEW, PERFECT F.B. RAILS, 75 lb. yard, R.B.S., chiefly 40ft. lengths.
1500 TONS UNUSED BUT STOCK RUSTY F.B. RAILS, 75 lb. yard, R.B.S., chiefly 36ft.
50 TONS NEW, SLIGHTLY DEFECTIVE F.B. RAILS, 80 lb. yard, Revised B.S. Section, lengths chiefly 40ft.
250 TONS SECOND-HAND F.B. RAILS, about 60 lb. yard, 24ft., 27ft., 30ft. and 45ft.
10 TONS SECOND-HAND COACH SCREWS, 6½in. by 1¼in., Standard Railway Pattern.
50 TONS MILD STEEL FLAT, 5in. by ½in., New but Stock Rusty, 15ft. to 26ft. chiefly.

WARD'S ALSO HAVE LARGE STOCKS OF ALL CLASSES OF OTHER RAILWAY MATERIALS

THOS. W. WARD LTD.

ALBION WORKS - - - SHEFFIELD
'Phone : 26311. 'Grams : "Forward."
E215 G

FOR SALE
BILLETER RADIAL ARM OPEN-SIDED HYDRAULIC SLIDEWAY GRINDER

Twin grinding heads ; table 9ft. 8in. by 2ft. 3in. ; covered bed ; pendent control.

F. J. EDWARDS, LTD.,

359–361, EUSTON ROAD,
LONDON, N.W.1.
EUSton 4681 & 3771.

E8902 G

HEAVY CURRENT RECTIFIER

FIVE Similar Units, each comprising Mains Transformer, 6600 volts, 50 cycles, 3-phase, with 6-phase outgoing supplying six SELENIUM RECTIFIERS. Each set having a D.C. output, 17 volts, 7000 amperes. Transformers and Rectifiers designed for service out-doors. In first-class condition.—The M.E.I. Co. Ltd., Upper Villiers Street, Wolverhampton. E8956 G

FOR SALE

FRED WATKINS (ENGINEERING) LTD.

STEAM BOILERS.—Cochrane Vertical (New), 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia., 100/150 lb. w.p.; reconditioned 8ft. 6in. down to 3ft. dia.; Economic 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p. 300 reconditioned Vertical Crosstube, all sizes.

AIR COMPRESSORS.—Two Belliss & Morcom 2500 c.f.m., 100 p.s.i., 550 h.p. motors ; also Broomwade 500, 400, 300, 200 and 130 c.f.m., all motorised ; and several others of various makes and capacities.

200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.

ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 200 h.p.

MOBILE ROAD CRANES.—10-ton Lorain lorry-mounted 30ft.–70ft. extendible jib ; 10-ton 33 R.B. track mounted, 40ft. jib ; 8½-ton Ransomes Diesel/Electric, 21ft. jib. 6-ton Coles Diesel/Electric, pneumatics, new 1948 (2) ; 6-ton Coles Diesel/Electric, solids ; 4-ton Coles Diesel/Electric, solids ; 1945 ; 4-ton Jones KL44, diesel, 1950 ; 3-ton Jones "Super 40" diesel, pneumatics (3).

OVERHEAD CRANES.—20/6-ton Vaughan 42ft. 3in. span, cab type (6) ; 20-ton King, 42ft. 3in. span, 400/3/50 ; 15-ton Booth, 37ft. span, 400/3/50; 15-ton Morris, 35ft. span, hand-operated ; 10-ton Morris, 48ft. span, 36ft. lift ; 10-ton Vaughan, 23ft. 6in. span, 400/3/50 ; 10-ton Vaughan, 21ft. span, 44ft. lift ; Wharton 7½-ton, 25ft. span, 400/3/50 ; 5-ton Henderson, 24ft. 7in. span, 1946 ; 5-ton Morris, 58ft. span, hand-operated ; 5-ton Royce, 2-motor crab, 440/3/50 ; 5-ton King, 29ft. 3in. span, power hoist, hand travel ; 5-ton Morris, 28ft. 6in. span, power hoist, hand travel ; 4-ton Morris, 19ft. span, 220V., d.c. (3) ; 3-ton Adamson, 48ft. span, 400/3/50 ; 2-ton Adamson, 34ft. span, 400/3/50 (2) ; 2-ton Morris, 18ft. span ; 2-ton Vaughan, 27ft. 6in. span, 2-motor ; majority of the above are unused.

DERRICK CRANES.—7-ton Anderson Grice, 100ft. jib, electric ; 7-ton Rushworth, hand, 30ft. jib ; 5-ton Wilson, electric, 70ft. jib ; 1½-ton Anderson Grice, hand, 40ft. jib.

RAIL CRANES.—18-ton Brownhoist, steam, 50ft. jib ; 10-ton Coles, steam, 40ft. jib ; 10-ton Grafton 34ft. jib, diesel conversion ; 8-ton Wilson, steam, 35ft. jib ; 5-ton Grafton, 35ft. jib, diesel conversion ; 5-ton Smith, 50ft. jib (2) ; 5-ton Cowans Sheldon, 50ft. jib.

LOCOS.—Fowler diesel, 150 h.p. (2) ; Barclay & Ruston 80/88 h.p. diesel ; Bagnall 14in. by 22in. (two oil-fired, one coal), Peckett, steam, 7in. by 12in., 1941 ; also 3 miles track, 24in. gauge, Bogies, Turnouts, &c.

STEEL PIPING.—50,000ft., 2in. Galvanised, new ; 60,000ft., 3in. black, new ; 5000ft., 8in. seamless ; 1000ft., 12in. seamless ; 500ft., 14in. seamless ; 400ft., 18in. riveted ; 280ft., 21in. o.d. welded flanged ; 3800ft., 21in. seamless flanged ; 500ft., 24in. riveted ; 1450ft., 27in. o.d. welded flanged ; 216ft., 48in. riveted : 216ft., 60in. riveted.

CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s. Immediate delivery.

VALVES.—Exceptional Surplus Ministry Lot. New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock all sizes, Parallel Slide Sluices, Gunmetal, Reducing and Check Valves. List on request.

STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons

MACHINE TOOLS.—Heenan & Froude Dynamometers, 1500 h.p. maximum, 18in. Dial Indicator (three) ; Scriven Plate Bending Rolls, 14ft. by ¾in. ; Berry Bending Rolls, 7ft. by ¾in. ; Tangye 200-ton Hydraulic Vertical Straightening Press, 15ft. by 3ft. table ; Herbert Miller, 61in. by 15in. table ; Pels Punch and Shears, ¾in capacity ; nine new 2 cwt. and 1 cwt. Pneumatic Hammers ; Bonn Hydraulic Tube Bender up to 20ft. by 4in. bore ; 40 kVA. Sciaky Spot Welding Machine ; Berry Guillotine, capacity 4ft. by 1in. ; Fielding Hydraulic Tube Bending Machine, 24in. stroke, up to 8in. capacity ; Sedgwick 6ft. by ¼in. Folding Machine ; Rushworth Plate Guillotine 4ft. by ¼in. ; Bliss 70-ton power press.

SLING ENGINEERING WORKS

COLEFORD, GLOS.
'Phone : Coleford 2271/2. E106 G

COMPLETE POWER PLANT COMPRISING :

2000kW pass out TURBO SET by Met.-Vickers, 250 lb. pressure, 250 deg. F., Reduction Gearbox and 2500kVA Alternator, 400/3/50, with control gear.
1000kW similar TURBO SET.
FOUR ECONOMIC BOILERS, each 12,500 lb. evaporation, 265 lb. working pressure, with Superheaters and Hodgkinson Stokers.
FOUR ECONOMIC BOILERS, each 8000 lb. per hour, 150 lb. working pressure, two worked 6 years and two 8 years, forced daught fans and Niagara stokers.

REED BROTHERS (ENGINEERING), LTD.,
Replant Works,
Woolwich Industrial Estate, London, S.E.18.
Tel.: Woolwich 7611/6. E8924 G

FOR SALE

HILGER H.216 BENDING MACHINE, 3in., 4in., 6in. and 8in. dies. Mint condition, seen working. —Colvin-Smith Limited, Gateshead, 8. E2722 G

NISSEN TYPE HUTS for sale. Prompt despatch of 16ft., 24ft., and 30ft. wide huts ; also "Romney" Huts, 35ft. wide, and "Blister" Hangars, 86ft. 6in. and 91ft. wide. These buildings are in various lengths and comprise steel framework with galvanised corrugated steel sheeting.—Full details from Dept. 115, J. Thorn and Sons, Ltd., Brampton Road, Bexleyheath, Kent. (Tel.: Bexleyheath 305). E113 G

FOR SALE

600

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UNUSED 979kVA, 6·6kV, 3-phase, 50 cycles Diesel Engine Driven Alternator Set incorporating engine by MIRRLEES BICKERTON & DAY, type JV.16 ; 1120 h.p. 16-cylinder, direct coupled to alternator by BRUSH ELECTRICAL, revolving field, mounted on soleplates with exciter. Engine complete with standard ancillaries, alternator with switchgear by REYROLLE, with automatic voltage regulator.

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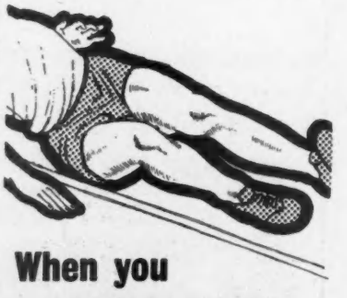

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March 1	Machine tools and miscellaneous stores.	M.O.A. Storage Depot, Byley, Nr. Middlewich, Cheshire. (Sale at Cheetham Town Hall, Manchester 8.)	J. H. NORRIS & SON, (Dept. L), 9, Albert Square, Manchester, 2. (Tel.: Blackfriars 8373.)
March 8–10	Machine tools and miscellaneous stores.	M.O.A. Storage Depot, Royal Arsenal, Woolwich, London, S.E.18.	FULLER, HORSEY, SONS & CASSELL (Dept. L), 10 Lloyd's Avenue, London, E.C.3. (Tel.: Royal 4861.)
March 15	Miscellaneous stores.	Central Ordnance Depot, Didcot, Berks.	SIMMONS & SONS (Dept. L), 12, Station Road, Reading, Berks. (Tel.: 54025.)
March 15–18	Vehicles, earth moving and lifting equipment.	M.O.A. Storage Depot, Ruddington, Notts.	WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 54272.)
March 22–23	Vehicles and miscellaneous stores.	Central Ordnance Depot, Bicester, Oxon.	MIDLAND MARTS, LTD. (Dept. L), Market Square, Bicester, Oxon. (Tel.: 73.)
March 30	Miscellaneous stores.	Northern Command Ordnance Sub-Depot, Barlow, Nr. Selby, Yorks.	BARTLE & SON (Dept. L), 50-52, Merrion Street, Leeds, 2. (Tel.: 2.0898.)

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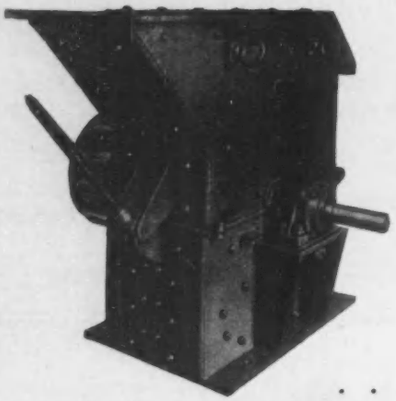

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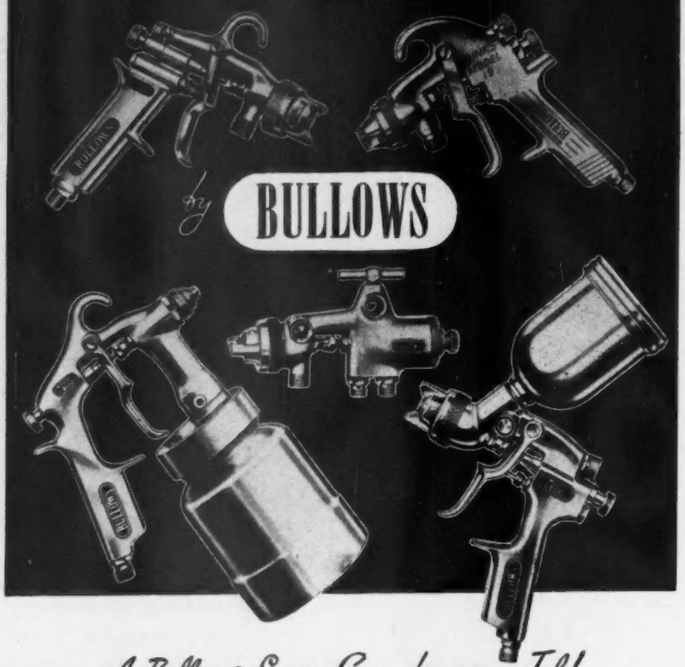

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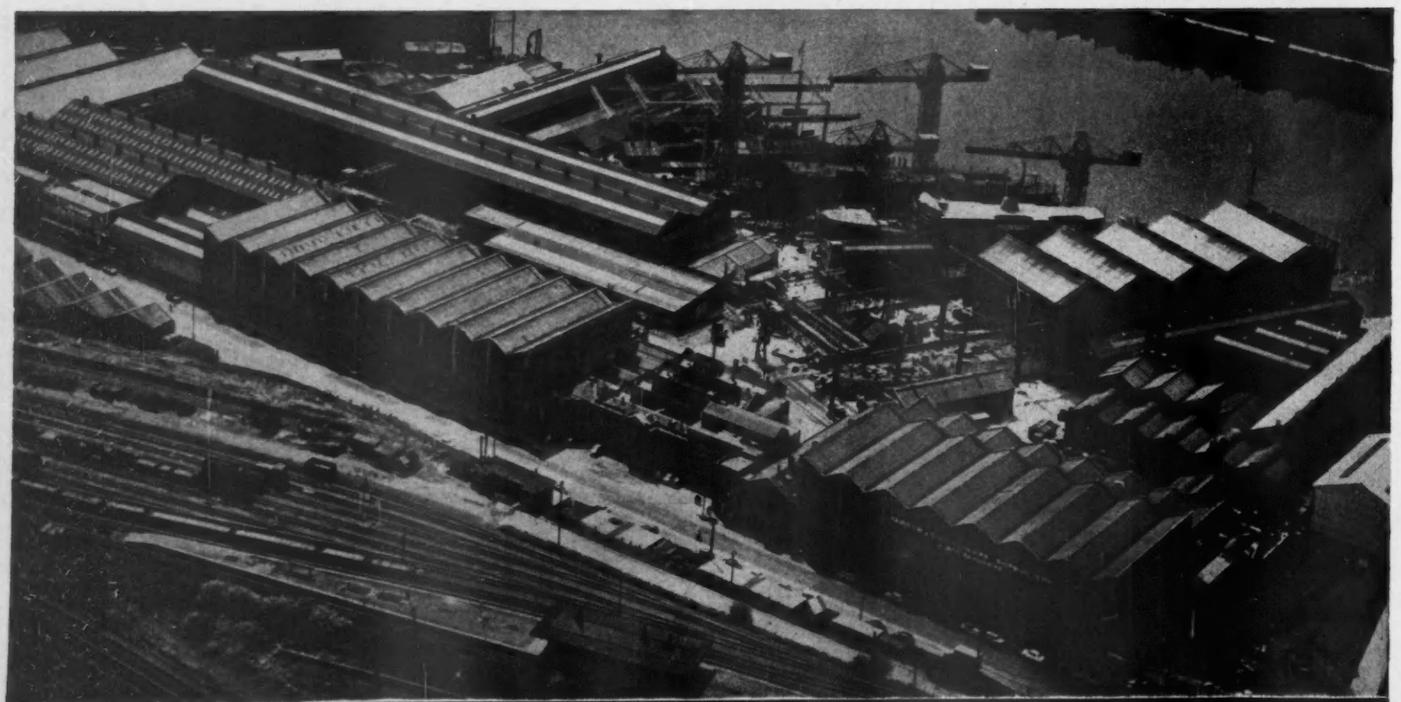

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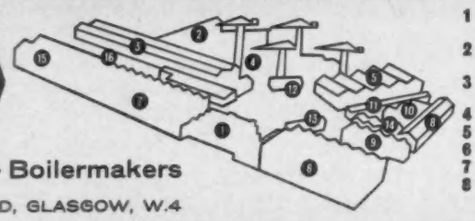

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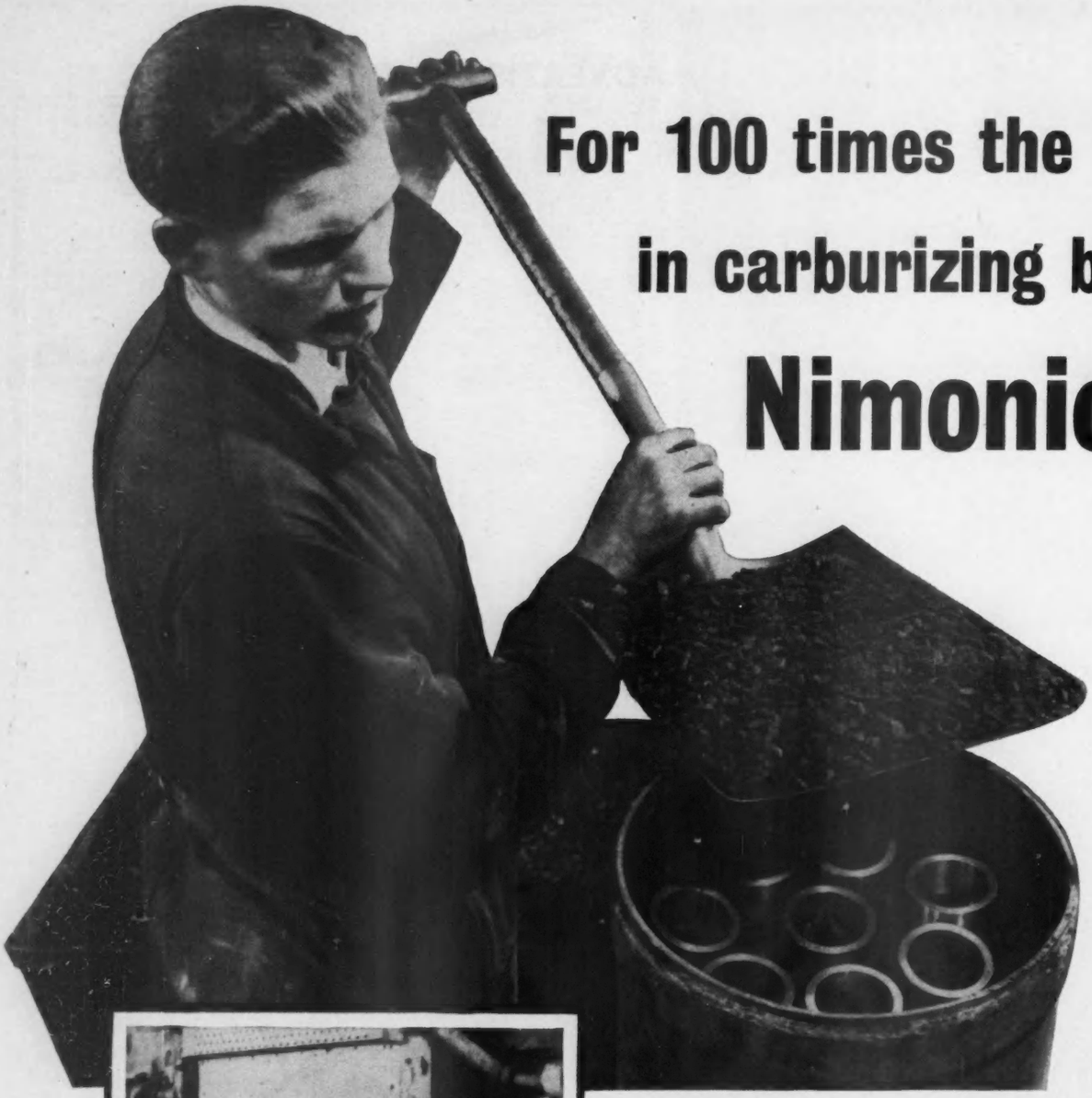

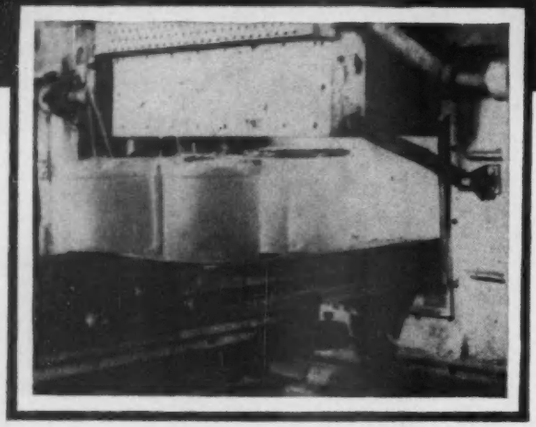

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